# METRO TORONTO & REGION

# REMEDIAL ACTION PLAN
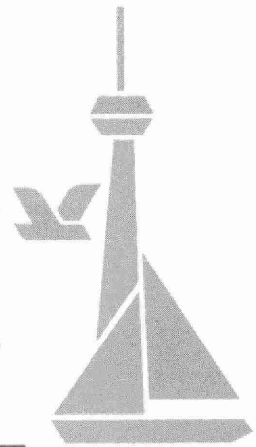
## METROPOLITAN TORONTO WATERFRONT
## WET WEATHER OUTFALL STUDY - PHASE I

**Remedial Action Plan**
**Plan d'Assainissement**

Canada ⊕ Ontario

COVER IMAGE SHOWING THE METROPOLITAN TORONTO WATERFRONT:
Scanned from the LANDSAT Thematic Mapper False Colour Infrared Image (1990 09 02),
archive of the Provincial Remote Sensing Office, Ministry of Natural Resources.
Vegetation appears in shades of red.  Bare soil and pavement appears in shades of turquoise.

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# WET WEATHER OUTFALL STUDY -- PHASE I

AUGUST 1995

Cette publication technique
n'est disponible qu'en anglais.

# METROPOLITAN TORONTO WATERFRONT

# WET WEATHER OUTFALL STUDY -- PHASE I

Reprint of report prepared for:

The Metropolitan Toronto and Region Remedial Action Plan

by

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and
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# ACKNOWLEDGEMENTS

## FOREWORD

This report has been prepared under the auspices of the Canada-Ontario Great Lakes Remedial Action Plan Program. Financial support for the study was provided by Environment Canada and the Ontario Ministry of Environment and Energy.

The Canada-Ontario Remedial Action Plan Steering Committee has reviewed this report and approved its publication. Approval does not necessarily signify that the contents reflect the views and policies of individual agencies, nor does mention of trade names or commercial products constitute endorsement or recommendatation for use.

This report is part of a series of technical investigations conducted in support of the Metropolitan Toronto and Region Remedial Action Plan (RAP). For additional technical reports or information on the RAP, contact the Metropolitan Toronto and Region RAP Coordinator at:

<div align="center">

Ontario Ministry of Environment and Energy
5775 Yonge Street
Toronto, Ontario
M2M 4J1

</div>

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# EXECUTIVE SUMMARY

## BACKGROUND

Remedial Action Plans (RAPs) are underway in Ontario for 17 areas of concern as identified by the International Joint Commission (IJC). The Toronto Waterfront has been designated as one of the 17 areas of concern. The IJC has recommended the development of a RAP in order to:

- provide coordinated and ongoing direction with respect to restoration of the waterfront to its desired uses; and to

- address the issues of concern which include swimming, aesthetics, fish consumption, aquatic sediments, aquatic biota, habitat and drinking water (Metro Toronto RAP, 1988).

The Ministry of the Environment and Environment Canada are working together with the public to jointly develop the RAP. An ecosystem approach will be used to restore water quality and protect the aquatic environment of the Metro Toronto Waterfront.

The RAP will identify the causes of pollution and proposed measures for remediation. One identified source of pollution is the direct discharge from one hundred and three (103) waterfront storm sewer outfalls, some of which, during rainfall periods, contain combined sewer overflow (combined sanitary sewage and stormwater runoff).

Wet weather discharges from sewer outfalls along the waterfront have contributed to:

- closure of beaches, due to high levels of bacteria, particularly for those outfalls which discharge combined sewage overflow;

- elevated levels of nutrients, organics and heavy metals originating from surface runoff; and

- locally stressed aquatic systems adjacent to specific outfalls (BEAK et al., 1987).

The Toronto Waterfront RAP team, in reviewing the findings from previous studies recognized a deficiency in the loadings database, specifically as it relates to the estimates of various contaminant inputs including storm and combined sewers. In an effort to better quantify contaminant inputs from direct sewer discharges to the waterfront, several studies were initiated by the Ontario Ministry of the Environment.

Collectively the studies will provide estimates of dry and wet weather contaminant loadings for a wide range of conventional and toxic organic pollutants from direct discharges along the City of Etobicoke, Scarborough and Toronto waterfronts.

The objective of this report is to present estimates of wet weather contaminant concentrations and loadings for storm and combined sewers located along the waterfront within the Cities of Etobicoke and Scarborough. The study area is shown in Figure 1.

Wet weather concentrations and loading estimates for direct discharges within the City of Toronto are being prepared in an ongoing study (Aquafor, 1991 in progress). Dry weather concentrations and loading estimates for direct discharges along the waterfront within the Cities of Etobicoke, Toronto and Scarborough have already been estimated (BEAK, 1991). Wet and dry weather contaminant loadings which discharge from the major tributaries to the waterfront are being estimated in an ongoing study (MOE/Metro Toronto 1991, in progress).

## SCOPE OF WORK

The scope of work involved the characterization of pollutant discharges and quantification of flow volumes to estimate contaminant loadings for all waterfront outfalls. The study components can be summarized by three tasks:

- a field program;
- development of a runoff prediction model and;
- analysis of contaminant discharges.

MUNICIPALITIES OF
METROPOLITAN TORONTO

LEGEND

Wet Weather Study Area

L204 Outfall Number

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METROPOLITAN TORONTO
WATERFRONT
DRY AND WET WEATHER
OUTFALL STUDIES

CATCHMENT AREAS AND OUTFALL NUMBERS

DIGITIZED DRAWING FROM 1:10000 OMB MAPS

| SURVEYED BY: | DATE: 89-12-12 | CONTRACT #: 8905/9 |
| DRAWN BY: J.MINAKER | CHECKED BY: B.GRECK | |
| SCALE: 1:50000 | | FIGURE 1 |

The field program consisted of measuring flow and collecting samples of urban runoff within the study area. Due to the large number of outfalls along the waterfront and limited resources, it was impractical to measure and sample runoff from all outfalls. Nine representative monitoring stations were selected which would characterize contaminant discharges from various land uses. Two additional stations were monitored to estimate loadings from a combined sewer overflow located upstream of the Metro Humber Sewage Treatment Plant (Berry Street overflow) and the Metro Main Sewage Treatment Plant bypass. A range of rainfall events were sampled because different quantities of rainfall directly affect the volume of discharge and may also affect the quality of the discharge.

The flow data collected at the representative monitoring stations and rainfall data collected during the study was then used in the development of a runoff prediction model. This data served to calibrate the model for application to the required waterfront catchments. In addition, historical rainfall data from a number of rain gauges in the Metropolitan Toronto area were analyzed in the selection of a typical rainfall year for model application. This data, along with historical flow data from area tributaries were analyzed to evaluate the seasonal variability in runoff discharge volumes.

The contaminant data collected was statistically analyzed to determine the variability in contaminant concentrations with discharge volumes and between stations. Summaries of Event Mean Concentrations (EMCs) were averaged to provide Average Event Mean Concentrations (AEMCs). For many contaminants special statistical techniques were used to analyze data with concentrations which were less than the detection limit. Estimates of contaminant loadings were computed as the product of the estimated average event mean concentration (AEMC) and the predicted runoff volumes. Estimates of seasonal loadings for the summer/fall and winter/spring periods and annual loadings were provided.

The estimated seasonal and annual loadings for 47 water quality parameters are presented in Tables 1, 2 and 3.

A summary is presented in Table 4 of the constituent concentrations observed in the following sources:

- dry weather outfalls (winter 1989 data);
- stormwater outfalls during wet weather (fall 1989 data);

## TABLE 1   SUMMARY OF ESTIMATED SUMMER/FALL LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 1,579,000 | 547,000 | 1,358,000 | 3,484,000 |
| Hardness | kg | 436,000 | 150,800 | 374,800 | 961,600 |
| Phenolics (4AAP) | kg | 35 | 12 | 30 | 77 |
| Total suspended solids | kg | 258,000 | 89,150 | 220,900 | 568,050 |
| Ammonium | kg | 499 | 172 | 430 | 1,101 |
| Nitrates | kg | 6,551 | 2,262 | 5,600 | 14,413 |
| Nitrite | kg | 107 | 37 | 92 | 236 |
| Total Kjeldhal Nitrogen | kg | 5,108 | 1,767 | 4,400 | 11,275 |
| Total Phosphorus | kg | 1,059 | 366 | 900 | 2,325 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 7,868 | 2,726 | 6,760 | 17,354 |
| Fecal Coliform MF | Tcts | 11,270 | 3,903 | 9,700 | 24,873 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 6 | 2 | 5 | 13 |
| Aluminum | kg | 3,489 | 1,207 | 3,000 | 7,696 |
| Arsenic | kg | 2 | 1 | 1 | 4 |
| Barium | kg | 97 | 33 | 83 | 213 |
| Cadmium | kg | 6 | 2 | 5 | 13 |
| Chromium | kg | 29 | 10 | 24 | 63 |
| Copper | kg | 249 | 86 | 210 | 545 |
| Iron | kg | 9,538 | 3,295 | 8,200 | 21,033 |
| Mercury | g | 122 | 42 | 100 | 264 |
| Manganese | kg | 353 | 122 | 300 | 775 |
| Nickel | kg | 22 | 7 | 19 | 48 |
| Lead | kg | 105 | 36 | 90 | 231 |
| Selenium | kg | 2 | 1 | 1 | 4 |
| Zinc | kg | 794 | 129 | 320 | 1,243 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 4,026 | 1,393 | 3,500 | 8,919 |
| Gamma-BHC | mg | 3,073 | 1,063 | 2,600 | 6,736 |
| 1,3,5-Trichlorobenzene | mg | 4,277 | 1,479 | 3,700 | 9,456 |
| 1,2,4-Trichlorobenzene | mg | 9,706 | 3,351 | 8,300 | 21,357 |
| 1,2,3-Trichlorobenzene | mg | 4,356 | 1,508 | 3,700 | 9,564 |
| Hexachlorobenzene | mg | 619 | 229 | 568 | 1,417 |
| PP DDE | mg | 317 | 117 | 291 | 726 |
| Alpha Chlordane | mg | 1,314 | 486 | 1,206 | 3,006 |
| Gamma Chlordane | mg | 1,161 | 429 | 1,066 | 2,657 |
| OP DDT | mg | 614 | 227 | 564 | 1,405 |
| PP DDT | mg | 2,125 | 786 | 1,951 | 4,861 |
| Dieldrin | mg | 1,546 | 572 | 1,420 | 3,537 |
| Hexachloroethane | mg | 349 | 129 | 321 | 799 |
| Hexachlorobutadiene | mg | 626 | 231 | 575 | 1,432 |
| Trichlorotoluene 2-4-5 | mg | 1,610 | 596 | 1,478 | 3,684 |
| Tetrachlorobenzene 1-2-3-5 | mg | 6,308 | 2,333 | 5,791 | 14,432 |
| Trichlorotoluene 2-6-A | mg | 1,482 | 548 | 1,361 | 3,391 |
| Pentachlorobenzene | mg | 1,203 | 445 | 1,104 | 2,752 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 527 | 182 | 450 | 1,159 |
| Acenaphthylene | g | 36 | 12 | 30 | 78 |
| Acenaphthene | g | 179 | 61 | 150 | 390 |
| Fluorene | g | 282 | 97 | 240 | 619 |
| Phenanthrene | g | 2,346 | 811 | 2,000 | 5,157 |
| Anthracene | g | 97 | 33 | 83 | 213 |
| Fluoranthene | g | 3,178 | 1,099 | 2,700 | 6,977 |
| Pyrene | g | 2,139 | 739 | 1,800 | 4,678 |
| Benzo (A) Anthracene | g | 708 | 245 | 600 | 1,553 |
| Chrysene | g | 1,406 | 486 | 1,200 | 3,092 |
| Benzo (B) Fluoranthene | g | 2,284 | 790 | 1,960 | 5,034 |
| Benzo (B-K) Fluoranthene | g | 1,501 | 519 | 1,300 | 3,320 |
| Benzo (A) Pyrene | g | 1,036 | 358 | 900 | 2,294 |
| Indeno (1-2-3 C-D) Pyrene | g | 498 | 172 | 430 | 1,100 |
| Dibenzo (A-H) Anthracene | g | 234 | 81 | 200 | 515 |
| Benzo (G-H-I) Perylene | g | 591 | 204 | 500 | 1,295 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

## TABLE 2    SUMMARY OF ESTIMATED WINTER/SPRING LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | SCARBOROUGH STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 3,131,000 | 1,093,000 | 3,488,000 | 7,712,000 |
| Hardness | kg | 864,000 | 302,000 | 962,300 | 2,128,300 |
| Phenolics (4AAP) | kg | 70 | 24 | 77 | 171 |
| Total suspended solids | kg | 510,000 | 178,000 | 568,600 | 1,256,600 |
| Ammonium | kg | 987 | 345 | 1,100 | 2,432 |
| Nitrates | kg | 12,962 | 4,525 | 14,400 | 31,887 |
| Nitrite | kg | 214 | 75 | 240 | 529 |
| Total Kjeldhal Nitrogen | kg | 10,126 | 3,534 | 11,300 | 24,960 |
| Total Phosphorus | kg | 2,099 | 733 | 2,300 | 5,132 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 15,590 | 5,440 | 17,350 | 38,380 |
| Fecal Coliform MF | Tcts | 22,338 | 7,797 | 24,900 | 55,035 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 12 | 4 | 13 | 29 |
| Aluminum | kg | 6,930 | 2,413 | 7,690 | 17,033 |
| Arsenic | kg | 4 | 1 | 3 | · 8 |
| Barium | kg | 194 | 68 | 200 | 462 |
| Cadmium | kg | 12 | 4 | 13 | 29 |
| Chromium | kg | 57 | 20 | 60 | 137 |
| Copper | kg | 495 | 172 | 550 | 1,217 |
| Iron | kg | 18,886 | 6,592 | 21,000 | 46,478 |
| Mercury | g | 242 | 85 | 270 | 597 |
| Manganese | kg | 700 | 244 | 760 | 1,704 |
| Nickel | kg | 45 | 15 | 50 | 110 |
| Lead | kg | 210 | 73 | 230 | 513 |
| Selenium | kg | 4 | 1 | 3 | 8 |
| Zinc | kg | 741 | 259 | 830 | 1,830 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 7,977 | 2,786 | 8,890 | 19,653 |
| Gamma-BHC | mg | 6,099 | 2,126 | 6,780 | 15,005 |
| 1,3,5-Trichlorobenzene | mg | 8,479 | 2,955 | 9,440 | 20,874 |
| 1,2,4-Trichlorobenzene | mg | 19,217 | 6,701 | 21,390 | 47,308 |
| 1,2,3-Trichlorobenzene | mg | 8,646 | 3,021 | 9,620 | 21,287 |
| Hexachlorobenzene | mg | 1,238 | 458 | 1,137 | 2,833 |
| PP DDE | mg | 635 | 235 | 583 | 1,452 |
| Alpha Chlordane | mg | ·2,628 | 972 | 2,412 | 6,012 |
| Gamma Chlordane | mg | 2,323 | 859 | 2,133 | 5,314 |
| OP DDT | mg | 1,228 | 454 | 1,127 | 2,809 |
| PP DDT | mg | 4,249 | 1,571 | 3,901 | 9,722 |
| Dieldrin | mg | 3,092 | 1,144 | 2,839 | 7,075 |
| Hexachloroethane | mg | 698 | 258 | 641 | 1,598 |
| Hexachlorobutadiene | mg | 1,252 | 463 | 1,149 | 2,864 |
| Trichlorotoluene 2-4-5 | mg | 3,221 | 1,191 | 2,957 | 7,369 |
| Tetrachlorobenzene 1-2-3-5 | mg | 12,615 | 4,665 | 11,582 | 28,863 |
| Trichlorotoluene 2-6-A | mg | 2,965 | 1,096 | 2,722 | 6,783 |
| Pentachlorobenzene | mg | 2,406 | 890 | 2,209 | 5,504 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 1,055 | 365 | 1,160 | 2,580 |
| Acenaphthylene | g | 73 | 25 | 80 | 178 |
| Acenaphthene | g | 358 | 124 | 390 | 872 |
| Fluorene | g | 565 | 195 | 620 | 1,380 |
| Phenanthrene | g | 4,694 | 1,623 | 5,170 | 11,487 |
| Anthracene | g | 195 | 67 | 220 | 482 |
| Fluoranthene | g | 6,355 | 2,198 | 7,000 | 15,553 |
| Pyrene | g | 4,278 | 1,480 | 4,720 | 10,478 |
| Benzo (A) Anthracene | g | 1,416 | 490 | 1,560 | 3,466 |
| Chrysene | g | 2,812 | 972 | 3,100 | 6,884 |
| Benzo (B) Fluoranthene | g | 4,569 | 1,580 | 5,040 | 11,189 |
| Benzo (B-K) Fluoranthene | g | 3,003 | 1,038 | 3,310 | 7,351 |
| Benzo (A) Pyrene | g | 2,072 | 717 | 2,280 | 5,069 |
| Indeno (1-2-3 C-D) Pyrene | g | 996 | 344 | 1,100 | 2,440 |
| Dibenzo (A-H) Anthracene | g | 469 | 162 | 520 | 1,151 |
| Benzo (G-H-I) Perylene | g | 1,184 | 409 | 1,300 | 2,893 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

## TABLE 3      SUMMARY OF ESTIMATED ANNUAL LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 4,710,000 | 1,640,000 | 4,846,000 | 11,196,000 |
| Hardness | kg | 1,300,000 | 452,800 | 1,337,100 | 3,089,900 |
| Phenolics (4AAP) | kg | 105 | 36 | 107 | 248 |
| Total suspended solids | kg | 768,000 | 267,150 | 789,500 | 1,824,650 |
| Ammonium | kg | 1,486 | 517 | 1,530 | 3,533 |
| Nitrates | kg | 19,513 | 6,787 | 20,000 | 46,300 |
| Nitrite | kg | 321 | 112 | 332 | 765 |
| Total Kjeldhal Nitrogen | kg | 15,234 | 5,301 | 15,700 | 36,235 |
| Total Phosphorus | kg | 3,158 | 1,099 | 3,200 | 7,457 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 23,458 | 8,166 | 24,110 | 55,734 |
| Fecal Coliform MF | Tcts | 33,608 | 11,700 | 34,600 | 79,908 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 18 | 6 | 18 | 42 |
| Aluminum | kg | 10,419 | 3,620 | 10,690 | 24,729 |
| Arsenic | kg | 6 | 2 | 4 | 12 |
| Barium | kg | 291 | 101 | 283 | 675 |
| Cadmium | kg | 18 | 6 | 18 | 42 |
| Chromium | kg | 86 | 30 | 84 | 200 |
| Copper | kg | 744 | 258 | 760 | 1,762 |
| Iron | kg | 28,424 | 9,887 | 29,200 | 67,511 |
| Mercury | g | 364 | 127 | 370 | 861 |
| Manganese | kg | 1,053 | 366 | 1,060 | 2,479 |
| Nickel | kg | 67 | 22 | 69 | 158 |
| Lead | kg | 315 | 109 | 320 | 744 |
| Selenium | kg | 6 | 2 | 4 | 12 |
| Zinc | kg | 1,535 | 388 | 1,150 | 3,073 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 12,003 | 4,179 | 12,390 | 28,572 |
| Gamma-BHC | mg | 9,172 | 3,189 | 9,380 | 21,741 |
| 1,3,5-Trichlorobenzene | mg | 12,756 | 4,434 | 13,140 | 30,330 |
| 1,2,4-Trichlorobenzene | mg | 28,923 | 10,052 | 29,690 | 68,665 |
| 1,2,3-Trichlorobenzene | mg | 13,002 | 4,529 | 13,320 | 30,851 |
| Hexachlorobenzene | mg | 1,858 | 687 | 1,705 | 4,250 |
| PP DDE | mg | 952 | 352 | 874 | 2,179 |
| Alpha Chlordane | mg | 3,941 | 1,458 | 3,619 | 9,018 |
| Gamma Chlordane | mg | 3,484 | 1,288 | 3,199 | 7,971 |
| OP DDT | mg | 1,842 | 681 | 1,691 | 4,214 |
| PP DDT | mg | 6,374 | 2,357 | 5,852 | 14,584 |
| Dieldrin | mg | 4,638 | 1,715 | 4,259 | 10,612 |
| Hexachloroethane | mg | 1,047 | 387 | 962 | 2,396 |
| Hexachlorobutadiene | mg | 1,878 | 694 | 1,724 | 4,296 |
| Trichlorotoluene 2-4-5 | mg | 4,831 | 1,787 | 4,435 | 11,053 |
| Tetrachlorobenzene 1-2-3-5 | mg | 18,923 | 6,998 | 17,374 | 43,295 |
| Trichlorotoluene 2-6-A | mg | 4,447 | 1,644 | 4,083 | 10,174 |
| Pentachlorobenzene | mg | 3,608 | 1,334 | 3,313 | 8,256 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 1,582 | 547 | 1,610 | 3,739 |
| Acenaphthylene | g | 109 | 37 | 110 | 256 |
| Acenaphthene | g | 537 | 185 | 540 | 1,262 |
| Fluorene | g | 847 | 292 | 860 | 1,999 |
| Phenanthrene | g | 7,040 | 2,434 | 7,170 | 16,644 |
| Anthracene | g | 292 | 100 | 303 | 695 |
| Fluoranthene | g | 9,533 | 3,297 | 9,700 | 22,530 |
| Pyrene | g | 6,417 | 2,219 | 6,520 | 15,156 |
| Benzo (A) Anthracene | g | 2,124 | 735 | 2,160 | 5,019 |
| Chrysene | g | 4,218 | 1,458 | 4,300 | 9,976 |
| Benzo (B) Fluoranthene | g | 6,853 | 2,370 | 7,000 | 16,223 |
| Benzo (B-K) Fluoranthene | g | 4,504 | 1,557 | 4,610 | 10,671 |
| Benzo (A) Pyrene | g | 3,108 | 1,075 | 3,180 | 7,363 |
| Indeno (1-2-3 C-D) Pyrene | g | 1,494 | 516 | 1,530 | 3,540 |
| Dibenzo (A-H) Anthracene | g | 703 | 243 | 720 | 1,666 |
| Benzo (G-H-I) Perylene | g | 1,775 | 613 | 1,800 | 4,188 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

- combined sewer overflows (fall 1989 data);
- water filtration plant backwash (winter and fall 1989 data); and
- water pollution control plants (fall 1989 data).

Data for these sources are compared to target levels represented by standards, objectives or criteria contained in the following documents:

- Metro Toronto Sewer Use Bylaw;
  - Discharges to sanitary sewer system;
  - Discharges to storm sewer system;

- Provincial Water Quality Objectives (PWQOs) and Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life, swimming areas or drinking water.

The target concentrations show a decrease in allowable level from the "sanitary sewer system by–law" through "storm water system by–law" to "receiving water". The target concentrations listed for sanitary sewers and stormwater systems are for discharges to these respective sewer systems. The target sanitary sewer concentrations are substantially higher than those for discharges to storm sewers because sanitary sewerage is treated at water pollution control plants (WPCPs) whereas storm sewerage is generally not treated prior to discharge. The target stormwater discharge to storm sewer targets are within a factor of two to five of PWQOs reflecting the fact that only a modest amount of dilution is available before ambient water conditions required by biota occur. Most of the parameters given in Table 4 have targets listed in the PWQOs. Several parameters including, TP, nitrate, iron, manganese, selenium, silver, total cyanide and arsenic have PWQO values but do not have target values for discharges to storm sewers. Table 5 presents a summary of the frequency of detection, PWQO and detection limit for all parameters tested.

## STATEMENTS

The following statements have been prepared based on data, analytical results and the computations prepared in this study.

TABLE 4.0(a):    COMPARISON OF CONCENTRATIONS MEASURED IN WATERFRONT STUDIES WITH VARIOUS WATER QUALITY CRITERIA

| Parameter | | Discharge to Sanitary Sewer By-Law Target Concentration | Discharge to Storm Sewer By-Law Target Concentration | PWQO Aquatic Life (Drinking Water) | Observed Concentration Dry Weather Outfall | Observed Concentration Wet Weather Outfalls | Observed Concentration RL Clark WFP Backwash | Observed Concentration WPCP Effluent | Observed Concentration Weather CSO's |
|---|---|---|---|---|---|---|---|---|---|
| BOD | (mg/L) | 300 | 15 | - | 7-19 | 420 | <1 | 11-27 | - |
| Fecal Coliforms | (CNT/dL) | - | 15 | - | 38,000-301,000 | 10,000-16E6 | <2 | 10-10$^5$* | 30,000-10E6 |
| SS | (mg/L) | 350 | 15 | 0 | 17-37 | 87-188 | 63-1100 | 13-19 | 85-156 |
| TP | (mg/L) | 10 | - | .03 | 0.2-0.5 | 0.3-0.7 | 0.5-0.9 | .48-.75 | .39-.77 |
| TKN | (mg/L) | 100 | - | - | 1.8-4 | 1.9-3 | 2.6-6.2 | .22-30 | 2.2-3.0 |
| Phenolics | (mg/L) | 1 | - | .001 | 4-6 | .014-.019 | <0.005 | .009-.011 | .018-.021 |
| NO$_3$ | (mg/L) | - | - | (10) | 3.1-7.9 | 1.1-2.1 | .33-.44 | 0.35-0.39 | .16-1.7 |
| Al | (mg/L) | 50 | - | - | .25-.35 | 1.2-2.5 | 21-29 | .098-.41 | 1.1-1.9 |
| Fe | (mg/L) | 50 | - | 0.3 | .63-1.0 | 2.7-7.2 | 3.5-6.0 | 1.7-2.4 | 3.1-7.6 |
| Cr | (mg/L) | 5 | 0.2 | 0.1 | 0.008-0.13 | .009-.025 | .023-.062 | .008-.011 | .006-.021 |
| Pb | (mg/L) | 5 | 0.05 | 0.025 | 0.008-0.012 | 0.038-0.055 | .013-.033 | .017-.021 | .049-.081 |
| Mn | (mg/L) | 5 | - | - | 0.11-.17 | -.12-.17 | 0.15-0.24 | .15-.26 | .19-.48 |
| Se | (mg/L) | 5 | - | 0.1 | <0.001 | <.001 | <0.001 | <.001 | .001 |
| Ag | (mg/L) | 5 | - | .0001 | <0.01 | .002-.005 | 0.007-0.25 | .007-.015 | - |
| Cu | (mg/L) | 3 | 0.01 | 0.005 | .040-0.071 | .045-.46 | .013-.054 | .011-.023 | .033-.12 |
| Ni | (mg/L) | 3 | 0.05 | 0.025 | .008-.012 | .009-.016 | 0.006-0.016 | .043-.068 | .006-.014 |
| Zn | (mg/L) | 3 | 0.05 | 0.030 | 0.42-.065 | .14-.26 | 0.019-0.18 | .054-.074 | .14-2.1 |
| Total Cyanide | (mg/L) | 2 | - | .005 | - | .005 | <0.005 | .031-.038 | |
| As | (mg/L) | 1 | - | 0.1 | .002-.004 | <.001 | 0.01-0.061 | <.001 | .001 |
| Cd | (mg/L) | 1 | 0.001 | .0002 | <0.002 | .001-.024 | <0.005 | .002-.004 | .001 |
| Hg | (mg/L) | 0.1 | 0.001 | 0.0002 | <0.00001 | .00004-.00006 | 0.000035-0.000058 | .0004-.0001 | |
| PCBs | (μg/L) | 0 | 0 | .001 | <0.02 | - | <0.001 | NC | - |
| Solvent Extractable | | - | - | - | - | 5-11 | | 2.2-2.6 | - |

* Plant Operating Data - lower end of range is for operating conditions using chlorination, while upper end is for periods of non-chlorination.

Reference:    Beak Consultants Limited and Paul Theil Associates Limited, 1991 Study of 1984 Dry Weather Discharges to the Metropolitan Toronto Waterfront, report submitted to the Ontario Ministry of the Environment.

TABLE 4.0(b):   COMPARISON OF CONCENTRATIONS (µg/L) MEASURED IN WATERFRONT STUDIES WITH GUIDELINES FOR ORGANIC PARAMETERS*

| Compound (All Units µg/L) | Guidelines | Observed Concentration Dry Weather Outfalls | Observed Concentration Wet Weather Outfalls | Observed Concentration WFP Backwash | Observed Concentration WPCP Effluent |
|---|---|---|---|---|---|
| Phenols | 2.0a | 8 | 17 | <0.7 | 11 |
| Toluene | 300b | 0.02 | - | <0.1 | <0.3 |
| Benzene | 300b | 0.02 | - | <0.1 | <0.3 |
| Alpha-BHC | 0.092c | 0.001 | 0.001 | 0.003 | <0.001 |
| Gamma-BHC | 0.186c | 0.0005 | 0.001 | 0.006 | 0.01 |
| Total PCB | 0.001d | <0.005 | <.25 | <0.005 | <0.005 |
| Anthracene | - | <0.02 | 0.051 | <0.1 | <0.001 |
| Fluoranthene | 42c | <0.02 | 0.782 | <0.1 | 0.007 |
| Pyrene | - | <0.02 | 0.615 | <0.1 | 0.016 |
| Benzo(A)Anthracene | - | <0.04 | 0.249 | <0.2 | <0.001 |
| Chrysene | - | <0.02 | 0.333 | <0.1 | 0.003 |
| Hexachlorobutadiene | 0.1b | <0.0004 | 0.00024 | <0.00005 | 0.0004 |
| Biz-2-Ethyl Hexyl Phthalate | 6b | 7.4 | - | 4 | <0.002 |
| Dichlorobenzene 1,2 | 2.5b | <.02 | - | <0.08 | <0.0001 |
| Dichlorobenzene 1,3 | - | <0.02 | - | <0.08 | <0.0003 |
| Dichlorobenzene 1,4 | 4.0b | <0.02 | - | <0.2 | <0.0003 |
| Trichlorobenzene 1,2,4 | 0.5b | 0.002 | 0.005 | 0.004 | 0.03 |
| Trichlorobenzene 1,2,3 | 0.9b | <.0001 | 0.002 | 0.007 | 0.008 |
| Trichlorobenzene 1,3,5 | 0.65b | <.00005 | <0.0004 | <0.0005 | 0.002 |
| Tetrachlorobenzene 1,2,3,4 | 0.1b | <.00005 | <0.0004 | <0.0005 | 0.009 |
| Pentachlorobenzene | 0.03b | <0.00005 | 0.0008 | <.0003 | 0.002 |
| Hexachlorobenzene | 0.0065b | <0.00005 | 0.0003 | <0.0003 | 0.004 |
| Heptachlor Epoxides and Heptachlor | 0.01b | <.00001 | <.00005 | <0.00001 | <0.00005 |

* Values which are "less than" are average of data above detection limit plus assignment of values at detection limit as one-half of detection limit. Values which do not have "less than" sign are calculated by probability distribution estimation technique.

Guideline Data Sources:

a) PWQO - Drinking Water.
b) USEPA - Drinking Water (represents a 0.0001 incremental cancer risk; recommended concentration is 0.
c) CWQG - Aquatic Life.
d) PWQO; alternate specification is zero tolerance limit for drinking water.

Reference:   Beak Consultants Limited and Paul Theil Associates Limited, 1991 Study of 1984 Dry Weather Discharges to the Metropolitan Toronto Waterfront, report submitted to the Ontario Ministry of the Environment.

TABLE 5: SUMMARY OF PARAMETER CODES, FREQUENCY OF DETECTION AND DETECTION LIMIT VALUES FOR THE WHOLE DATA SET

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **General Chemistry** | | | | | | |
| Alkalinity (as CaCO$_3$) | ALKT | 0.02 | mg/L | 56 | 56 | 100 |
| Biochemical Oxygen Demand (5–Day) | BOD$_5$ | 1.0 | mg/L | 2 | 2 | 100 |
| Cyanide – Avl. Unfil. React. | CCNAUR | 0.001 | mg/L | 55 | 13 | 24 |
| Chloride | CLIDUR | 0.01 | mg/L | 1 | 1 | 100 |
| Chemical Oxygen Demand | COD | 2.0 | mg/L | 54 | 54 | 100 |
| Dissolved Organic Carbon | DOC | 0.5 | mg/L | 2 | 1 | 50 |
| Hardness | HARDT | 1.0 | mg/L | 5 | 5 | 100 |
| Phenolics (4AAP) | PHNOL | 0.20 | $\mu$g/L | 54 | 54 | 100 |
| Total Dissolved Solids | RSF | 1.0 | mg/L | 1 | 1 | 100 |
| Total Suspended Solids | RSP | 0.3 | mg/L | 54 | 54 | 100 |
| Total Solids | RST | 1.0 | mg/L | 54 | 54 | 100 |
| Solvent Extractable (Organic) | SOLEXT | 1.0 | mg/L | 49 | 44 | 90 |
| Sulphide | SSIDUR | 0.001 | $\mu$g/L | 3 | 1 | 33 |
| Ammonium | NNHTFR | 0.05 | mg/L | 61 | 15 | 23 |
| Nitrates | NNOTFR | 0.05 | mg/L | 61 | 48 | 74 |
| Nitrite | NNO2FR | 0.005 | mg/L | 54 | 43 | 66 |
| Total Kjeldahl Nitrogen | NNTKUR | 0.05 | mg/L | 61 | 61 | 100 |
| Total Phosphorus | PPUT | 0.02 | mg/L | 61 | 60 | 99 |
| **Heavy Metals** | | | | | | |
| Silver | AGUT | 0.0005 | mg/L | 65 | 42 | 65 |
| Aluminum | ALUT | 0.01 | mg/L | 65 | 65 | 100 |
| Arsenic | ASUT | 0.001 | mg/L | 65 | 9 | 14 |
| Barium | BAUT | 0.005 | mg/L | 65 | 65 | 100 |
| Cadmium | CDUT | 0.0002 | mg/L | 65 | 33 | 51 |
| Chromium | CRUT | 0.001 | mg/L | 65 | 56 | 86 |
| Copper | CUUT | 0.0002 | mg/L | 65 | 63 | 97 |
| Iron | FEUT | 0.01 | mg/L | 65 | 64 | 99 |
| Mercury | HGUT | 0.01 | $\mu$g/L | 65 | 58 | 89 |
| Manganese | MNUT | 0.001 | mg/L | 65 | 65 | 100 |
| Nickel | NIUT | 0.001 | mg/L | 65 | 60 | 92 |
| Lead | PBUT | 0.005 | mg/L | 65 | 64 | 99 |
| Selenium | SEUT | 0.001 | mg/L | 65 | 8 | 12 |
| Zinc | ZNUT | 0.001 | mg/L | 65 | 65 | 100 |
| **Bacteriology** | | | | | | |
| E. Coli | ECMF | 4.0 | CH | 39 | 38 | 97 |
| Fecal Coliform MF | FCMF | 4.0 | CH | 38 | 37 | 97 |
| Fecal Streptococcus MF | FSMF | 4.0 | CH | 39 | 38 | 97 |
| Pseudomonas Aeruginosa MF | PSAMF | 2.0 | CH | 39 | 35 | 89 |

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **Organochloride Pesticides/ Chlorobenzenes/PCBs** | | | | | | |
| PCB | P1PCBR | 10.0 | ng/L | 51 | 5 | 10 |
| HCB | X2HCB | 0.1 | ng/L | 51 | 25 | 49 |
| Heptachlor | P1HEPT | 0.1 | ng/L | 51 | 7 | 14 |
| Aldrin | P1ALDR | 0.1 | ng/L | 51 | 13 | 26 |
| p,p–DDE | P1PPDE | 0.1 | ng/L | 51 | 22 | 43 |
| Mirex | P1MIRX | 0.5 | ng/L | 51 | 1 | 2 |
| Alpha BHC | P1BHCA | 0.1 | ng/L | 51 | 51 | 100 |
| Gamma BHC | P1BHCG | 0.1 | ng/L | 51 | 49 | 96 |
| Beta BHC | P1BHCB | 0.1 | ng/L | 51 | 1 | 2 |
| Alpha Chlordane | P1CHLA | 0.2 | ng/L | 51 | 22 | 43 |
| Gamma Chlordane | P1CHLG | 0.2 | ng/L | 51 | 20 | 39 |
| o,p–DDT | P1OPDT | 0.5 | ng/L | 51 | 12 | 24 |
| p,p–DDT | P1PPDT | 0.5 | ng/L | 51 | 18 | 35 |
| p,p–DDD | P1PPDD | 0.5 | ng/L | 51 | 9 | 18 |
| Heptachlor Epoxide | P1HEPE | 0.1 | ng/L | 51 | 3 | 6 |
| Thiodan I | THIO–I | 0.2 | ng/L | 51 | 9 | 18 |
| Thiodan II | THIO–II | 0.4 | ng/L | 51 | 9 | 18 |
| Thiodan Sulphate | THIO–SO4 | 0.4 | ng/L | 51 | 9 | 18 |
| Dieldrin | P1DIEL | 0.2 | ng/L | 51 | 32 | 63 |
| Endrin | P1ENDR | 0.4 | ng/L | 51 | 5 | 10 |
| Oxychlordane | P1OCHL | 0.2 | ng/L | 51 | 2 | 4 |
| Methoxychlor | P1DMDT | 0.4 | ng/L | 51 | 9 | 18 |
| Hexachloroethane | P1HCE | 0.1 | ng/L | 51 | 29 | 57 |
| 1,3,5–Trichlorobenzene | X2125 | 0.2 | ng/L | 51 | 26 | 51 |
| 1,2,4–Trichlorobenzene | X2124 | 0.2 | ng/L | 51 | 29 | 57 |
| 1,2,3–Trichlorobenzene | X2123 | 0.1 | ng/L | 51 | 24 | 47 |
| Hexachlorobutadiene | X1HCBD | 0.1 | ng/L | 51 | 32 | 63 |
| 2,4,5–Trichlorotoluene | X2T245 | 0.1 | ng/L | 51 | 21 | 41 |
| 2,3,6–Trichlorotoluene | X2T236 | 0.1 | ng/L | 51 | 9 | 18 |
| 1,2,4,5–Tetrachlorobenzene | X21245 | 0.1 | ng/L | 51 | 13 | 26 |
| 1,2,3,5–Tetrachlorobenzene | X21235 | 0.1 | ng/L | 51 | 37 | 73 |
| 26A–Trichlorotoluene | X2T26A | 0.1 | ng/L | 51 | 29 | 57 |
| 1,2,3,4–Tetrachlorobenzene | X21234 | 0.1 | ng/L | 51 | 14 | 28 |
| Pentachlorobenzene | X2PNCB | 0.1 | ng/L | 51 | 32 | 63 |
| **Polynuclear Aromatic Hydrocarbons** | | | | | | |
| Naphthalene | PNNAPH | 0.5 | ng/L | 52 | 52 | 100 |
| Acenaphthylene | PNACYN | 0.5 | ng/L | 52 | 39 | 75 |
| Acenaphthene | PNACNE | 0.5 | ng/L | 52 | 49 | 94 |
| Fluorene | PNFLUO | 0.5 | ng/L | 52 | 49 | 94 |
| Phenanthrene | PNPHEN | 0.5 | ng/L | 52 | 51 | 98 |
| Anthracene | PNANTH | 0.5 | ng/L | 52 | 46 | 88 |
| Fluoranthene | PNFLAN | 0.5 | ng/L | 52 | 52 | 100 |
| Pyrene | PNPYR | 0.5 | ng/L | 52 | 52 | 100 |

TABLE 5:       SUMMARY OF PARAMETER CODES, FREQUENCY OF DETECTION AND DETECTION LIMIT
(Cont'd)       VALUES FOR THE WHOLE DATA SET

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **Polynuclear Aromatic Hydrocarbons** (Cont'd) | | | | | | |
| Benzo (A) Anthracene | PNBAA | 0.5 | ng/L | 52 | 49 | 94 |
| Chrysene | PNCHRY | 0.5 | ng/L | 52 | 50 | 96 |
| Benzo (B) Fluoranthene | PNBBFA | 0.5 | ng/L | 52 | 45 | 87 |
| Benzo (B-K) Fluoranthene | PNBKF | 0.5 | ng/L | 52 | 44 | 85 |
| Benzo (A) Pyrene | PNABAP | 0.5 | ng/L | 52 | 43 | 83 |
| Indeno (1-2-3-C-D) Pyrene | PNINP | 0.5 | ng/L | 52 | 41 | 79 |
| Dibenzo (A-H) Anthracene | PNDAHA | 0.5 | ng/L | 52 | 31 | 60 |
| Benzo (G-H-I) Perylene | PNGHIP | 0.5 | ng/L | 52 | 42 | · 81 |

CH   =   Counts/100 mL.
N    =   Number of samples.
ND   =   Number of detected samples.

1.  Of the 88 water quality parameters tested, all were detected in wet weather. Heavy metals were in general detected in more than 80 percent of the samples.

Trace organic substances which were detected in more than 50 percent of the samples include:

| Substance | Frequency of Detection (%) |
|---|---|
| phenols | 100 |
| Alpha BHC | 100 |
| Gamma BHC | 96 |
| Dieldrin | 63 |
| Hexachloroethane | 57 |
| 1,3,5–Trichlorobenzene | 51 |
| 1,2,4–Trichlorobenzene | 57 |
| Hexachlorobutadiene | 63 |
| 1,2,3,5–Tetrachlorobenzene | 73 |
| 26A–Trichlorotoluene | 57 |
| Pentachlorobenzene | 63 |

All PAHs listed below were detected for 60 to 100 percent of the samples.

| Substance | Frequency of Detection (%) |
|---|---|
| Naphthalene | 100 |
| Acenaphthylene | 75 |
| Acenaphthene | 94 |
| Fluorene | 94 |
| Phenanthrene | 98 |

- Anthracene                             88
- Fluoranthene                           100
- Pyrene                                 100
- Benzo (A) Anthracene                   94
- Chrysene                               96
- Benzo (B) Fluoranthene                 87
- Benzo (B-K) Fluoranthene               85
- Benzo (A) Pyrene                       83
- Indeno (1-2-3 C-D) Pyrene              79
- Dibenzo (A-H) Anthracene               60
- Benzo (G-H-I) Perylene                 81

Total PCBs were detected in 10 percent of the samples.

The frequency of detected trace organics in wet weather discharges exceeds those measured in dry weather discharges.

2.   Measured wet weather discharges exceed Provincial Water Quality Objectives (PWQOs) for 9 parameters (fecal coliforms, total phosphorus, phenolics, iron, lead, aluminum, copper, zinc and cadmium). Furthermore, all of the constituent concentrations (i.e. lead) exceed PWQOs by an order of magnitude. Five constituent concentrations exceed the Storm Sewer By-Law Target Concentration (biological oxygen demand, suspended solids, copper, zinc and cadmium).

3.   When compared to dry weather discharge concentrations, wet weather discharge concentrations are significantly higher by an order of magnitude for BOD, Fecal Coliform, Total Suspended Solids, Nitrates, Aluminum, Copper and Cadmium.

4. Statistical analysis of the water quality data shows that there is no significant relationship between the Event Mean Concentration (EMC) and the outfall discharge volume. This allows for the calculation of contaminant loading as the product of the average EMC (AEMC) and event runoff volume.

5. Statistical analysis showed that the AEMC is independent of land use type. The lack of difference between the AEMCs and the different land uses may, in part, be due to such factors as atmospheric deposition being uniformly distributed over the area and the land use patterns within the study area (i.e., a direct comparison of distinct land uses was not possible as all commercial and industrial sewersheds contained some residential lands).

6. Comparison of the AEMC from stormwater discharges, stormwater discharges which contained CSO and the Main WPCP bypass indicated the following:

   – contaminant concentrations generally show no significant difference between discharges of stormwater runoff and CSO containing stormwater runoff for all parameter groups except bacteria. This may be explained by the high degree of sewer separation within the combined sewer systems monitored;

   – the Main WPCP bypass showed significantly higher concentrations usually by as much as an order of magnitude for most parameters in each parameter group with the greatest differences occurring for Ammonia, Total Phosphorus and Bacteria.

7. Water quality concentrations for outfalls containing CSO were considerably lower than those reported in literature data (NURP, TAWMS, UGLCCS). These lower concentrations are attributed to the high degree of sewer separation which has occurred within the combined sewer areas.

   Water quality concentrations for outfalls not containing CSO were within the range or within an order of magnitude of those observed in other studies.

8.	The distribution of precipitation over a year is fairly uniform. However, literature and stream flow data for several local watersheds suggested that runoff volumes generated during the winter/spring period are approximately twice those generated during summer/fall period. This observation was used as the basis for estimating winter runoff volumes and loadings.

While the annual dry weather discharge volume from all waterfront outfalls is about the same as the wet weather volume generated from the Etobicoke and Scarborough waterfront outfalls, wet weather discharges provide significantly higher contaminant loadings for many parameters.

9.	When compared to dry weather discharges, wet weather loadings from storm sewer outfalls are a significant source of bacteria, heavy metals and organic contaminants. Wet weather loadings to the Etobicoke and Scarborough waterfronts compared to dry weather loadings for the Etobicoke, Toronto and Scarborough waterfront are found to be:

	–	3 orders of magnitude higher for bacteria;

	–	2 orders of magnitude higher for Total Suspended Solids, Cadmium, Mercury, Selenium, Fluoranthene, Pyrene, Chrysene, 1,2,3–Trichlorobenzene and 1,3,5–Trichlorobenzene; and

	–	1 order of magnitude higher for Total Phosphorus, Iron, Lead, Nickel, Arsenic, Anthracene, Benzo(a)Anthracene and 1,2,4–Trichlorobenzene.

10.	The wet weather loadings for a given catchment are directly dependant on the estimated runoff volume as the loadings were calculated based on the AEMC, and flow volume. Thus, the six largest catchments (outfalls L204, L403C, L308 and L309 in Etobicoke, and 904 and 903 in Scarborough) contribute 50 percent of the annual loadings. On average, the remaining catchment areas each contribute 2.0 percent of the annual loading.

The annual discharge volume from the Metro Main WPCP bypass is approximately 5 percent of the annual discharge from all of the Etobicoke and Scarborough waterfront outfalls. The Metro Main WPCP however services a much larger sewerage area of 26750 ha. This area is approximately seven times greater than the Etobicoke and Scarborough waterfront drainage area.

11. The Main WPCP bypass, a single discharge source, may contribute estimated loadings of Ammonium and Total Phosphorus in excess of wet weather loads from all outfalls discharging from Etobicoke and Scarborough. Furthermore, the bypass discharge loadings of Phenolics, TKN, bacteria, Silver, Barium, Iron, Chromium and Mercury are within the same order of magnitude as total outfall loadings. The higher loading is attributed to significantly higher concentrations in bypass discharges compared to storm sewer outfall discharges. Bypass loadings of toxic organic parameters is less than the loadings from storm sewer outfalls.

12. The contaminant concentrations and estimated loadings as provided in this report may be used to set priorities for remediating wet weather discharges from storm sewers along the Etobicoke and Scarborough waterfronts.

# METROPOLITAN TORONTO WATERFRONT
# WET WEATHER OUTFALL STUDY
# PHASE I

## 1 — INTRODUCTION

### 1.1 Background

Remedial Action Plans (RAPs) are underway in Ontario for 17 areas of concern as identified by the International Joint Commission (IJC). The Toronto Waterfront has been designated as one of the 17 areas of concern. The IJC has recommended the development of a RAP in order to:

- provide coordinated and ongoing direction with respect to restoration of the waterfront to its desired uses; and to

- address the issues of concern which include swimming, aesthetics, fish consumption, aquatic sediments, aquatic biota, habitat and drinking water (Metro Toronto RAP, 1988).

The Ministry of the Environment (MOE) and Environment Canada are working together with the public to jointly develop the RAP. An ecosystem approach will be used to restore water quality and protect the aquatic environment of the Metro Toronto Waterfront.

The RAP will identify the causes of pollution and proposed measures for remediation. Two sources are direct and indirect discharges to the Metro Toronto Waterfront from:

- Five Water Pollution Control Plants (WPCP): Lakeview, Humber, Main, Highland Creek and the North Toronto WPCP which is located adjacent to the Don River;

- Backwash water from three Water Filtration Plants: R.C. Harris, R.L. Clark, and Easterly;

- Six watersheds: Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek and Rouge River;

- Direct discharge from one hundred and three (103) waterfront storm sewer outfalls, some of which contain combined sewer overflow;

- Non-contact cooling water from a few industrial sources;

- Agricultural and rural drainage;

- Atmospheric wet and dry fallout;

- Groundwater seepage; and

- Spills which drain through ditches and sewers.

Wet weather discharges from sewer outfalls along the waterfront have contributed to:

- closure of beaches, due to high levels of bacteria, particularly for those outfalls which discharge combined sewage overflow (combined sanitary sewage and stormwater runoff);

- elevated levels of nutrients, organics and heavy metals originating from surface runoff; and

- locally stressed aquatic systems adjacent to specific outfalls (BEAK et al., 1987).

Several previous studies in the Metropolitan Toronto area (MOE, 1986) have characterized discharges of urban runoff. These studies have, however, concentrated on indirect discharges to the waterfront and have limited their assessment of loadings to conventional contaminants, bacteria or heavy metals. Recent studies of synthetic organic substances in both Ontario and the United States have found concentrations above detection limits in urban runoff (e.g., Marsalek and Schroeter, 1984 and NURP, 1986). Furthermore, many of these contaminants are toxic, persistent in the natural environment, and may produce adverse environmental and human health effects.

The Toronto Waterfront RAP team, in reviewing the above-noted studies, recognized a deficiency in the database, specifically as it relates to the estimation of various contaminant inputs from storm and combined sewers which discharge directly to the waterfront. This was identified in a report prepared by Environment Canada (1988) in which the need for "a toxic survey to provide improved estimates of loadings of toxic organics from sewer outfalls and water pollution control plant discharges" was stated.

In support of the Metro Toronto RAP, and in an effort to better quantify the impact of direct discharges to the waterfront, several studies were initiated by the Ontario Ministry of the Environment. Collectively, these studies will estimate dry and wet weather contaminant loadings for a wide range of conventional and toxic organic parameters from storm sewers, combined sewer overflows, water treatment and wastewater treatment plants, and watercourses which discharge directly to the waterfront.

The objective of this report is to present estimates of wet weather contaminant concentrations and loadings from storm and combined sewers which are located along the waterfront within the Cities of Etobicoke and Scarborough. Wet weather concentrations and loading estimates for waterfront discharges within the City of Toronto are being prepared in an ongoing study (Aquafor, 1991). Dry weather concentrations and loading estimates for direct discharges within the Cities of Etobicoke, Toronto and Scarborough have already been estimated (BEAK, 1991). Wet and dry weather loadings discharged from six major tributaries along the waterfront are being evaluated in an ongoing study (MOE, Metro Toronto 1991).

Collectively, the loading estimates which are established in the dry and wet weather studies may then be used by the RAP team and other agencies to assess the relative importance of these discharges in comparison to other contaminant sources and to assist in the development of the Remedial Action Plan.

## 1.2 Description of the Study Area and Sources of Contaminant Discharges

The study area consists of the waterfront catchments within the Cities of Etobicoke and Scarborough which drain directly to Lake Ontario (see Figure 1.1). Within this area, there are a total of 45 storm and combined sewer outfalls.

MUNICIPALITIES OF
METROPOLITAN TORONTO

TOWN OF VAUGHAN    TOWN OF MARKHAM

NORTH YORK

SCARBOROUGH

ETOBICOKE    YORK

EAST YORK

CITY
OF
TORONTO

LAKE    ONTARIO

SCARBOROUGH

TORONTO

LAKE    ONTARIO

ETOBICOKE

HUMBER BAY

ONTARIO
PLACE

TORONTO
ISLAND
AIRPORT

TORONTO
INNER
HARBOUR

TORONTO OUTER
HARBOUR

TORONTO
ISLANDS

LAKE    ONTARIO

LEGEND

☐   Wet Weather Study Area

L204   Outfall Number

paul theil associates limited
consulting engineers
21 Coventry Road, Brampton, Ontario  L6T 4V7

METROPOLITAN TORONTO
WATERFRONT
DRY AND WET WEATHER
OUTFALL STUDIES

CATCHMENT AREAS AND OUTFALL NUMBERS

DIGITIZED DRAWING: FROM 1:10000 OMB MAPS

| SURVEYED BY: | DATE: 89-12-12 | CONTRACT #: 8985/8 |
| DRAWN BY: J.MINAKER | CHECKED BY: B.OPECK | |
| SCALE:  1:50000 | | FIGURE  1.1 |

Areas within Metropolitan Toronto are serviced either by a separated sewer system or a combined sewer system. The separated sewer system uses: (i) sanitary sewers to transport domestic sewage from households and other sources directly to the WPCPs for treatment prior to discharge to the receiving water body; and (ii) storm sewers to transport runoff from rainfall events directly to the nearest watercourse. A combined sewer system conveys both sanitary sewage and storm runoff in the same pipe. During periods of increased flow caused by rainfall or snowmelt, combined trunk sewers and/or the WPCPs cannot accommodate the increased flow rates. Accordingly, combined sewers overflow or treatment plants bypass some of the combined sewage to the receiving body of water.

The Etobicoke waterfront catchment area is bounded by Etobicoke Creek to the west, the Humber River to the east, the Queen Elizabeth Way to the north and Lake Ontario to the south. There are 28 storm sewer outfalls within this area. The total sewershed area of 1,200 hectares represents approximately 12 percent of the total area within the City of Etobicoke.

The catchment areas within the City of Etobicoke are serviced by separated storm and sanitary sewers. Some storm sewers, in addition to conveying runoff during rainfall events, are also known to convey industrial cooling water discharges (BEAK, 1991).

Table 1.1 lists the Etobicoke Outfalls, their catchment areas and land uses. The catchment areas range from 4 to 380 hectares in size. The outfall with the largest catchment area is L204, representing 31 percent of Etobicoke's waterfront catchment area. The major land uses for the Etobicoke waterfront catchment area are residential and industrial at 69 and 17 percent, respectively (see Table 1.3).

The Scarborough waterfront catchment area is approximately bounded by Victoria Park Avenue to the west, the Rouge River to the east, Kingston Road to the north and Lake Ontario to the south. This area is approximately 2,700 hectares in size and represents 14 percent of the drainage area within the City of Scarborough. Six outfalls west of Bluffers Park or Brimley Road receive drainage from both separated storm and combined sewer systems. The area serviced by combined sewers is older relative to the other waterfront areas in Etobicoke and in Scarborough east of Brimley Road.

TABLE 1.1:     ETOBICOKE WATERFRONT OUTFALLS AND CATCHMENT AREAS

| Etobicoke Outfall Name [1] | Catchment Area (ha) | Land Use [2] | Study Catchment Names [3] |
|---|---|---|---|
| L102 | 28.2 | RES | E1 |
| L103 | 9.7 | RES/IND | E2 |
| L104 | 8.9 | RES | E3 |
| L105 | 12.7 | RES/COM | E3 |
| L201 | 48.6 | RES/IND | E4 |
| L202, L203A | 67.4 | RES/IND | E4 |
| L203B | 10.4 | RES | E5 |
| L204 (L203B) | 379.5 | IND/RES/INST | E5 |
| L205 | 27.5 | INST | E5 |
| L301 | 11.1 | RES | E6 |
| L302 | 5.7 | RES/INST | E7 |
| L303 | 18.9 | RES | E7 |
| L304 | 8.0 | RES/OPEN | E7 |
| L305 | 12.1 | RES | E7 |
| L306 | 4.9 | RES | E7 |
| L307 | 3.9 | RES | E7 |
| L308 | 72.0 | IND/RES/COM | E8 |
| L309 | 53.8 | IND/RES | E8 |
| L401 | 20.1 | RES | E9 |
| L402 | 8.9 | RES | E9 |
| L403 | 44.7 | RES | E9 |
| L403C | 195.0 | RES/IND/INST | E10 |
| L404 | 62.3 | RES/IND/COM | E11 |
| L405, L406, L407, L408 | 83.1 | OPEN | E12 |
| TOTAL | 1197.4 | | |

1     Outfall names from municipal maps.
2     Land uses greater than 10% of the watershed area in order of size highest to lowest.
3     Names of catchments, multiple references indicate lumped catchments.

TABLE 1.2:     SCARBOROUGH WATERFRONT OUTFALLS AND CATCHMENT AREAS

| Scarborough Outfall Name [1] | | Catchment Area (ha) | Land Use [2] | Study Catchment Name [3] |
|---|---|---|---|---|
| 914 | (L1) | 34.4 | RES | S1 |
| 914 | (L1) | 45.6 | OPEN/RES | S1A |
| 912 | (L2) | 105.5 | RES/IND/COM | S2 |
| 910 | (L3) | 60.5 | RES/OPEN/IND | S3 |
| 908 | (L4) | 148.5 | INST/OPEN/RES | S4 |
| 906 | (L5) | 27.3 | RES/OPEN/INST | S5 |
| 900A | (L6) | 161.1 | RES/INST/OPEN | S6 |
| 900B | (L6) | 102.0 | RES | S6A |
| 904 | | 180.9 | RES/OPEN | S7 |
| 918 | | 134.4 | RES/OPEN | S8 |
| 901 | | 180.9 | RES | S9 |
| 903 | | 285.9 | RES | S10 |
| 931, 933, 935 | | 92.0 | RES/IND/OPEN | S11 |
| 925 | | 174.3 | IND/OPEN | S12 |
| 913 | | 102.9 | RES | S13 |
| 911, 909 | | 40.1 | IND/RES | S14 |
| 915 | | 89.2 | RES | S15 |
| 927 | | 120.4 | RES | S16 |
| Discharge to Marsh | | 42.9 | IND | S17 |
| 919 | | 250.9 | RES | S18 |
| TOTAL | | 2689.3 | | |

1     Outfall names from municipal maps.
2     Land uses greater than 10% of the watershed area in order of size highest to lowest.
3     Catchments shown on Figure 2.3.

TABLE 1.3:     WATERFRONT LAND USE DISTRIBUTION

| Land Use | Etobicoke Waterfront (Percent) | Scarborough Waterfront (Percent) | Average of Two Waterfronts (Percent) |
|---|---|---|---|
| Residential | 69 | 66 | 67 |
| Institutional | 3 | 8 | 6 |
| Commercial | 3 | 1 | 2 |
| Industrial | 17 | 10 | 13 |
| Open | 8 | 15 | 12 |

Waterfront outfalls within the City of Scarborough, their catchment areas and land uses are given in Table 1.2. The catchment areas range from 27 to 286 hectares in size. The outfalls convey runoff from industrial, commercial, residential and open space areas along with internal combined sewer overflows. The outfall with the largest catchment area is 903, representing 11 percent of the Scarborough waterfront catchment area. The major land uses for the Scarborough waterfront catchment area are residential and open space at 66 and 15 percent, respectively (see Table 1.3).

The Metro Main WPCP receives sanitary and combined sewage from the cities of York, Toronto, East York and the City of Scarborough. The total sewerage area in 26570 ha (UMA 1989). In recent years, the combined sewer system in the City of Scarborough has undergone a fair amount of sewer separation to reduce quantities of stormwater conveyed to the Main WPCP. Much of the stormwater runoff in the City of Scarborough is now collected by storm sewers. The remaining combined sewer system is small, however, interconnections by means of combined sewer overflow discharges to the storm sewers exist.

## 1.3 Scope of Work

Historically, discharges from storm sewers were considered relatively "clean" and were not thought to be significant sources of contaminants relative to discharges from sewage treatment plants or combined sewer overflows. However, many studies in the last 20 years have shown that discharges from storm sewers can be a major source of pollutant loadings due to washing off of accumulated contaminants on the land. Sources of this contamination include nutrients and pesticides spread on lawns, heavy metals and exhaust emissions from automobiles and vehicular traffic, petroleum and chemical spills in industrial areas, bacterial contamination from fecal droppings of domestic pets and birds, atmospheric deposition, and direct or indirect connections from the sanitary sewer system.

Most of the wet weather runoff volumes are generated from impervious areas (i.e., roads, parking lots and roofs). These areas also have limited natural treatment capability and are therefore likely to convey a majority of the contaminant loadings. Pervious or grassed areas do contribute significant volumes of runoff during severe storm events or during winter periods when the ground is frozen.

Combined sewers, in addition to conveying the contaminants as described above, will also convey high levels of nutrients, ammonia and bacteria associated with sanitary inputs from residential areas.

Furthermore, contaminant levels of various non–conventional parameters may be significant depending upon the source or type of industrial area which is served.

Water Pollution Control Plants may also discharge significant loadings of various parameters (e.g. ammonia, phosphorus, TKN, bacteria and some heavy metals) in bypassing of primary treated or combined sewage at or upstream of the plant.

The scope of work involved the characterization of pollutant discharges and quantification of flow volumes to estimate contaminant loadings for all waterfront outfalls. The study components can be summarized by three tasks:

- a field program;
- development of a runoff prediction model and;
- analysis of contaminant discharges.

Further details with respect to the field program and analytical techniques which were used is given in Chapters 2.0 through 4.0.

## 2  -  STUDY APPROACH

### 2.1  Field Program for Runoff Quantity and Quality Measurements

The primary objective of the field program was to collect water quantity and quality data representative of the catchment areas within the Cities of Etobicoke and Scarborough. In designing the field program, the following factors were considered:

- the runoff volumes and constituent concentrations from storm and combined sewers are likely to be different;

- the runoff volumes and constituent concentrations may vary based on land use;

- the conveyance of urban runoff and the associated constituents during a rainfall event is a dynamic process. Significant variations in flow volume and constituent concentrations will therefore occur during the course of an event;

- the runoff volumes and constituent concentrations will vary between events;

- the seasonal flows and associated constituent loadings may vary;

- for a given event, the runoff volumes and constituent loadings may vary between outfalls and;

- for a given outfall, there are many constituents which could be monitored.

The collection and analysis of water quality and quantity samples from each of the 45 outfalls for any reasonable time period would be extremely onerous and expensive to undertake. For this reason, a field program to collect representative samples which could then be used to extrapolate flow volumes and constituent loadings for the remaining areas was designed. The program, and the logic for selecting the program is outlined below.

A total of eleven sites were initially selected (see Table 2.1 and Figures 2.1 to 2.3) for collection of water samples. See also Appendix 1 for specific monitoring locations. Continuous flow monitoring

TABLE 2.1:     MONITORING SITES

| Station Number | Location Name | Location Description | Land Use(s) |
|---|---|---|---|
| 1 | Main STP Bypass | Chamber downstream of bypass gate | Mixed, Bypass of primary effluent |
| 2 | Berry Street CSO, Etobicoke | Manhole at overflow weir on Stephen Drive and Berry Road | Mixed, combined sewer overflow |
| 3 * | L308, Etobicoke | Second Street between Lakeshore Boulevard and Lakeshore Drive | Residential and industrial with industrial cooling water |
| 4 | L102, Etobicoke | Fourth Street and Lake Promenade | Residential and commercial |
| 5 | Browns Line, Etobicoke | Jellicoe Avenue and Foch Avenue | Residential and industrial |
| 6 | Kingston Road 1, Scarborough | Kingston Road at Kennedy Road | Commercial |
| 7 | Cecil CSO, Scarborough | End of Cecil Crescent | Residential |
| 8 * | E11 CSO, Toronto | Greenwood Race Track and Eastern Avenue | Mixed |
| 9 * | Beachgrove, Scarborough | Ditch crossing Beachgrove Drive at the CNR Tracks | Industrial and residential |
| 10 | Kingston Road 2, Scarborough | Kingston Road at Faircroft Boulevard | Residential and commercial |
| 11 | Brooklawn, Scarborough | Brooklawn Avenue at Sunny Point Crescent | Residential |

\*     Dry Weather Outfall Study (BEAK and Theil, 1991) Outfall Monitoring Locations.

**Figure 2·1**



*ETOBICOKE*

- WET WEATHER
  MONITORING LOCATION

paul theil associates limited

FIGURE 2·2

TORONTO

WET WEATHER
MONITORING LOCATION

Figure 2·3



SCARBOROUGH

HWY. 401

Rouge River

Creek

S16

S13

S15

MEADOWVALE RD.

CENTENNIAL ROAD

PORT UNION ROAD

S18

S17

S14

LAWRENCE AVENUE

MORNINGSIDE AVE.

S12

S10

S11

#9
BEECHGROVE

Highland

MARKHAM ROAD

KINGSTON ROAD

S9

BRIMLEY ROAD

McCOWAN RD.

DANFORTH RD.

KENNEDY RD.

BIRCHMOUNT RD.

WARDEN AVENUE

S8

#10 KINGSTON RD 2

S7

#11 BROOKLAWN

S6

#7 CECIL CSO

S4

S5

#6 KINGSTON RD 1

LAKE          ONTARIO

S3

SCARBOROUGH
BLUFFS

ROAD

S1      S2

• WET WEATHER
  MONITORING LOCATION

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and water quality sampling was carried out at ten of the sites (physical limitations made flow monitoring at the WPCP bypass impractical) for approximately three months. In general, samples were collected for a minimum of 8 events. The sites were selected based on various factors, including:

- drainage area;
- land use type;
- availability of singular land use within the catchment;
- type of sewershed (i.e., combined or storm); and
- special conditions (see below).

The dominant land use within the study area is residential. Residential areas comprise approximately 67 percent of the land use while industrial and commercial areas comprise 14 percent and 2 percent, respectively. The remaining areas, approximately 17 percent, are generally open space.

Most catchment areas within the study area are comprised solely of a singular land use type and many of these are residential.

Nine of the eleven sites which were selected represent the following land use mixes:

- residential (3 sites);
- commercial (1 site);
- residential/industrial (3 sites); and
- residential/commercial (2 sites).

The other two sites were selected to monitor a large combined sewer overflow referred to as the Berry Street overflow and the bypass of a primary treated effluent from the Metro Main WPCP. The Berry Street overflow is the last regulator within the Humber River sewershed which limits flow to the Humber WPCP. Schematical flow plans for each WPCP are provided in Appendix 1.

Seven of the sites selected are serviced by storm sewers while two of the sites, one which was located in the City of Scarborough and the other in the City of Toronto, are serviced by combined sewers in which most of the domestic sewage has been separated.

All of the sites which were selected for monitoring discharge directly to Lake Ontario, with the exception of Station Number 5 (Browns Line). The Browns Line station discharges just upstream of

the mouth of the Etobicoke Creek. This site was selected as it has a high industrial land use component.

### 2.1.1                 Flow Monitoring and Water Quality Sampling Program

The collection of representative urban runoff flow data and water quality samples during wet weather conditions requires the use of special procedures and equipment. Several factors influenced the sampling protocol and equipment selection in this study including the requirement to collect:

- samples which account for the variability in flow volume and constituent concentration throughout the course of the runoff event;

- an adequate sample volume in order that the analysis of up to 88 water quality parameters could be carried out; and

- runoff volumes and constituent concentrations over a range of events.

Many of the parameters analyzed are known as trace organics or priority pollutants. These parameters are persistent and toxic in the natural environment and are generally found in very low concentrations. Analytical procedures for these parameters require sample volumes considerably larger than those used for conventional water quality parameters, such as total phosphorus or bacteria. In this study, the sample volume for the analysis of trace organics was increased from 1 litre to 16 litres in order to improve the detection limit. An additional sample volume of 4 litres was used for the analysis of the remaining parameters. The collection of the 20 litre sample representative of mean conditions for the entire event, required special customized retrofitting of sampling equipment.

Twenty litre flow proportionate composite water quality samples were collected to account for the variability of runoff concentrations caused by non-uniform washoff rates during a rainfall event. Variation in the washoff rate is a function of several factors but is dominated by factors such as interevent period, varying rainfall intensity and the nature of the runoff surface.

The flow monitoring equipment used was Montedoro-Whitney Q-Loggers. The Q-Logger is a portable electronic data logger which measures both depth and velocity. The depth and velocity sensors are both contained within a single probe which is installed at the invert of the sewer pipe. Velocity is measured by a Doppler ultrasonic sensor. The Q-Logger is programmed and readings are

retrieved using a portable computer (Montedoro–Whitney, 1988). This equipment provided all the flow monitoring requirements for this study.

The flow meters were set to measure flow every 5 minutes. This time step was considered adequate for determining event runoff volumes as it was short enough to capture peak flows and large enough so as not to generate excessive amounts of data. Flow measurements were made using the velocity area method, i.e., independent depth and velocity measurements were used to calculate the rate of flow. The flow data were retrieved and processed using Q–base and Lotus 1–2–3 software.

The sampler triggering device on the Q–Logger has three settings. The first setting is a threshold depth which initiates the sampling cycle. The second setting is a totalizer volume which is preset. Once flow has accumulated to the preset volume, a sample is collected. As the flow rate increases, the preset volume is obtained quicker and the sampler will sample more frequently. This results in the collection of a larger sample volume at the higher rates of flow. The last setting establishes the threshold flow above the threshold depth. The samplers were set to use a higher flow setting to minimize possible sampling of dry weather flows. An illustration of the result of these settings are shown in Figure 2.4. The final setting used for each station are listed in Appendix 1.

Representative composite samples were obtained by collection throughout the event. The flow metering equipment was used to trigger an automatic wastewater sampler for the collection of small sample (1 litre) volumes. An example is illustrated in Figure 2.4.

It was not possible to collect 20 litre samples for each event due to the variability of rainfall events both in duration and total depth. For small events, less than 20 litres would be collected and for larger events, the 20 litre sample would generally be collected during the initial stages of the event. Throughout the course of the study, it was necessary to adjust the preset sampling settings to accommodate the type of events anticipated.

ISCO Model 2700 samplers were used to collect the water quality samples. These samplers use peristaltic pumps. The only material in contact with this pumping system is silicone rubber tubing. This system minimizes cross-contamination of samples. One of the programming features of this sampler is the capability of the device to accept triggering for sample collection from an external signal such as a flow meter. The standard sampler capacity for a composite sample in a glass container is 9.5 litres (ISCO, 1986). Retrofitting of the samplers for the collection of 20 litres required disconnection

EXAMPLE OF FLOW PROPORTIONATE SAMPLING

Brooklawn Station 11 Nov. 8 1989

S=time of sampling
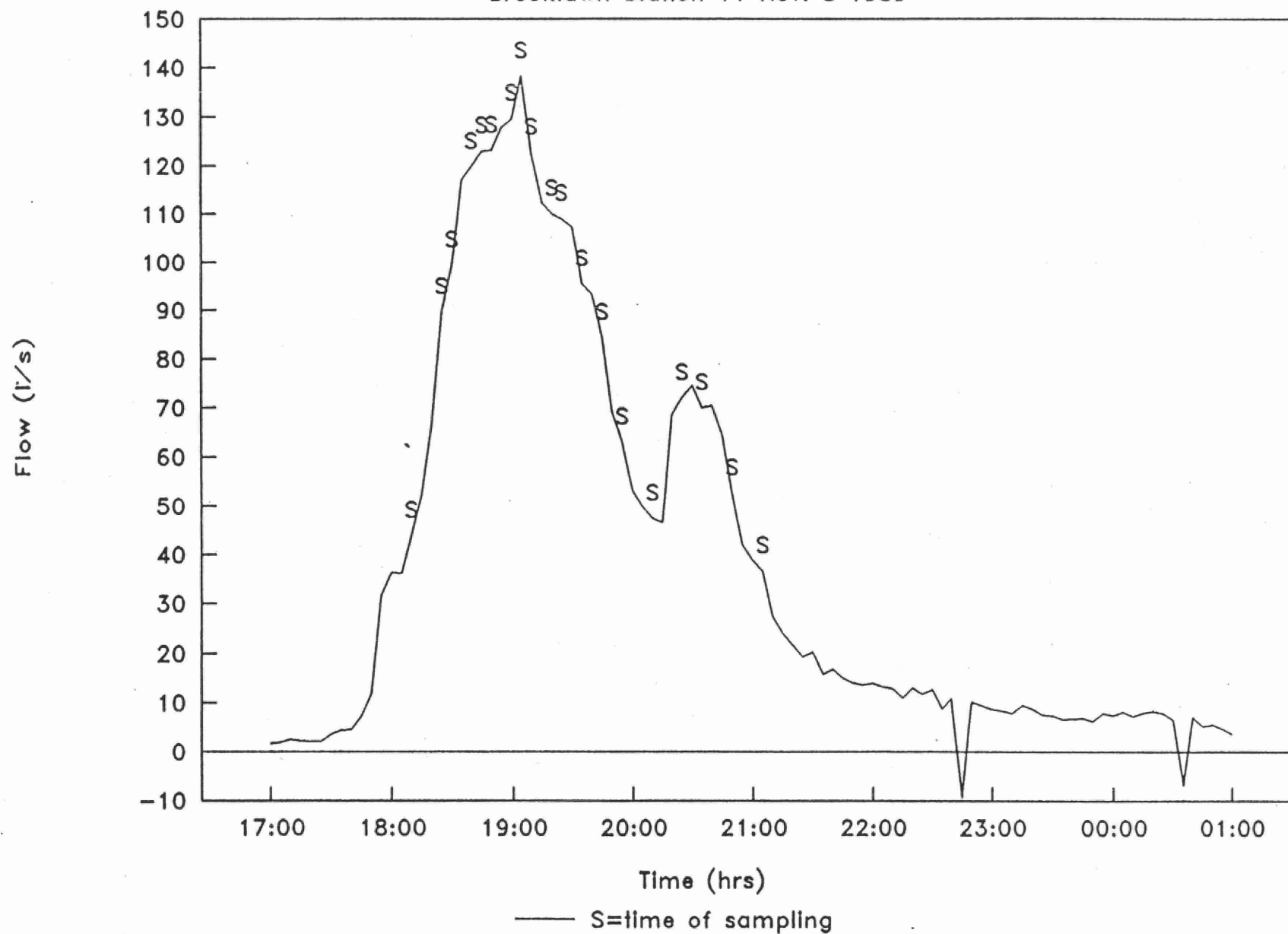
FIGURE 2·4

of the standard pump effluent hose from the sampler distribution arm and extending the hose with teflon tubing for discharge directly into a larger 23 litre glass jug external to the sampler.

The samplers were turned on during installation and remained in a stand-by mode until they were actuated by the flow meters. The actuation by the flow meter was based on a preset threshold water level. The threshold level was initially set based on information available from the recent dry weather study of waterfront outfalls (BEAK, 1991) and the prevailing conditions at time of installation. Throughout the course of the study, adjustment of the threshold level was necessary in order to account for different base flow water levels within the sewers and, in some locations, the backwater effects from Lake Ontario.

Once the 20 litre samples were collected, they were retrieved and prepared for submission to Ministry of the Environment laboratories, generally within 24 hours of collection. Sample preparation required the volume collected to be split into the appropriate bottles for analysis. At all times, all equipment and sample bottles were cleaned and preserved as required, following Ministry of the Environment sample collection, preservation and submission protocol. This protocol is presented in Appendix 1. Requests for analysis were prioritized based on the volume collected. If 16 litres was collected, the analysis of organic parameters took priority. Any additional volume was used for the other parameters. Sample volumes less than 16 litres did not allow for the analysis of organics and, therefore, only the remaining parameters were analyzed.

## 2.2        Sample Handling and Analytical Methods

To ensure a high level of quality and consistency during the field sampling phase, specific procedures were established prior to initiating the sampling program. A pre-designed field form was prepared in order to ensure that all pertinent field data was collected and that the required equipment checks and maintenance procedures were performed. All sampling team members completed a "hands-on" dry run of sample handling and equipment reset procedures. Included in the training was a review of safety procedures, handling of preservative chemicals, sewer confined space entry requirements and safety equipment.

Sample bottles, pre-cleaned by MOE staff, were used for the submission of all samples except those to be analyzed for trace organic parameters (16 litre samples). The 16 litre samples were submitted in amber, 4 litre bottles which were purchased and cleaned using the required washing protocol.

Parameters analyzed in this study are given in Table A1.1 (Appendix 1). Standard analytical methods (MOE, 1988) were used by the laboratories to analyze for chemical concentrations and bacterial densities. Measurements of conductivity and pH were obtained by the field staff at the time of sample preparation. Measurements of trace organic parameters were made by a private laboratory contracted by the MOE for purposes of this study. Interim data reports were generated by the MOE of all data as it became available. The final data results were received on a PC formatted disk from the MOE for data analysis.

# 3 – METHODOLOGY FOR ESTIMATING FLOW VOLUMES

The data collected from the field program provided a basis for estimating flow volumes and contaminant concentrations for the monitored sites. This section outlines the analytical method used to estimate discharge volumes from the unmonitored catchments. This chapter has been divided into the following sections.

- precipitation records;
- estimation of summer/fall wet weather runoff volumes;
- estimation of summer/fall CSO volumes;
- estimation of winter/spring wet weather runoff volumes;
- urban runoff measurements;
- runoff model calibration; and
- predicted urban runoff volumes.

## 3.1 Precipitation Records

The amount of precipitation will strongly impact the volume of wet weather discharge from a sewershed. Precipitation volumes vary significantly between events, seasons and years. Furthermore, for a given event the variation within a given area may vary substantially depending upon whether the storm was centred over the area. In order to determine representative runoff volumes, reasonable precipitation records must be available. Outlined below is the methodology used to select precipitation records for this study.

Historical rainfall data was obtained in this study and analyzed for the selection of a typical year of rainfall. These records were then used in the development of a computer simulation model to predict runoff volumes. As is discussed below, detailed modelling was only used for the summer/fall season. A more simplified approach was used for the winter/spring season due to the uncertainties of estimating volumes for frozen and spring runoff conditions. For this reason, detailed rainfall data was only collected and analyzed for the months of May to October.

A small working group which was made up of members from municipal, provincial and federal agencies was formed. Meetings were held to discuss the availability of data and procedures for selecting a typical rainfall year.

The criteria which was established for selecting rainfall data for continuous simulation included:

- measurement of local rainfall from a gauging station located within the Toronto Waterfront Area which would be representative of rainfall along the waterfront and could be used by this and future studies; and

- a year of rainfall data where rainfall patterns such as intensity, volume and frequency were consistent with the long-term mean for the selected site.

Historical hourly rainfall data from seven Atmospheric Environmental Services (AES) stations located within the Metropolitan Toronto Waterfront area were examined. A list of these stations and their lengths of record is provided in Table 3.1. Upon review of these data and discussions with the working group, the Etobicoke, Greenwood and Sherbourne sites were eliminated as they were no longer in operation and were removed in the early 1980s. As well, it was considered desirable to select a station which could be used by future studies of a similar nature. Two other stations (the Island Airport and Old Weston Road) were considered to have poor records not suitable for the analysis required. The remaining stations were Toronto (Bloor) and Ellesmere (Scarborough).

The rainfall databases for each of these two stations were edited to exclude any data for the November to April period and then analyzed. Three computer programs were considered for the analysis of these databases. One of the programs (PRCPSTAT; no official documentation) which was used by the Ministry of the Environment for the TAWMS studies was not available for use on a personal computer. A second program which has been used in the United States was not readily available. The third program which was used for the analysis is the Stormwater Management Model; specifically, the Rainfall Block (SWMM 4.0). This program was selected as it provided the basic analytical capabilities and could handle Atmospheric Environment Service (AES) formatted data.

The following statistics were generated by the SWMM program for each of the two stations for May to October data:

- total seasonal rainfall;
- average event duration;
- average event intensity;

TABLE 3.1:       AES HISTORICAL HOURLY RAINFALL DATA

| Station Name | Station Number | From Yr Mo | To Yr Mo | Years of Data | Comments |
|---|---|---|---|---|---|
| Toronto (Bloor) | 6158350 | 1937/11 | 1988/10 | 51 | Longest period of record. |
| Ellesmere | 6158520 | 1966/06 | 1988/10 | 22 | May be removed. |
| Etobicoke | 6158525 | 1963/12 | 1988/10 | 25 | No longer in operation. |
| Greenwood | 6158575 | 1966/04 | 1981/07 | 15 | No longer in operation. |
| Island A | 6158665 | 1971/05 | 1988/10 | 17 | Poor data. |
| Sherbourne | 61587PP | 1966/06 | 1979/10 | 13 | No longer in operation. |
| Old Weston Road | 6158764 | 1966/04 | 1988/09 | 22 | Poor data. |

- average event depth; and
- number of events per year.

Each of these parameters, to some degree, will affect the annual estimates of runoff volume. The most significant parameter, however, is the total seasonal rainfall. Results of this analysis for each of the two stations are illustrated in Figure 3.1 and Table 3.2. Upon review of these results, the year 1980 was selected as the typical rainfall year for estimating runoff volumes for the May to October season.

Through discussions with the working group, it was decided to use the rainfall data from a single station. Both the Ellesmere and Bloor Street stations had some disadvantages. The Bloor station has moved several times in its history and the quality of the data was questioned. The Ellesmere station on the other hand, is not as close to the waterfront, has a relatively shorter period of record and was likely going to be removed. Based on the above considerations, it was decided that the Bloor station would be used.

The ranking of events by volume for the Bloor station for the 1980 summer/fall season is illustrated in Figure 3.2. The data shows that approximately 50 percent of the summer/fall volume is generated by the 7 largest events which represents 11 percent of the rainfall events for this period. Sixty–five percent of the events had a precipitation volume of less than 5 mm.

The same level of analysis of precipitation data was not conducted for the winter/spring season (November to April) as detailed modelling was not used to estimate flows for this period. However, the relative distribution of total annual precipitation between the two seasonal periods was established. The monthly distribution of precipitation based on 51 years of records for the Bloor Station (AES Summaries) is presented in Figure 3.3. Figure 3.3 shows that for each of the two periods selected (summer/fall and winter/spring), the total rainfall is approximately equal at 400 mm. The average annual quantity of precipitation is 800 mm.

## 3.2 Estimation of Summer/Fall Wet Weather Runoff Volumes

Computer simulation modelling was used to estimate discharge volumes from all separated sewer systems discharging to the Etobicoke and Scarborough waterfronts for the summer/fall period (May to October). The U.S. EPA Stormwater Management Program (SWMM 4) Runoff Block was used in

FIGURE 3·1



BLOOR STATION
SUMMER/FALL RAINFALL
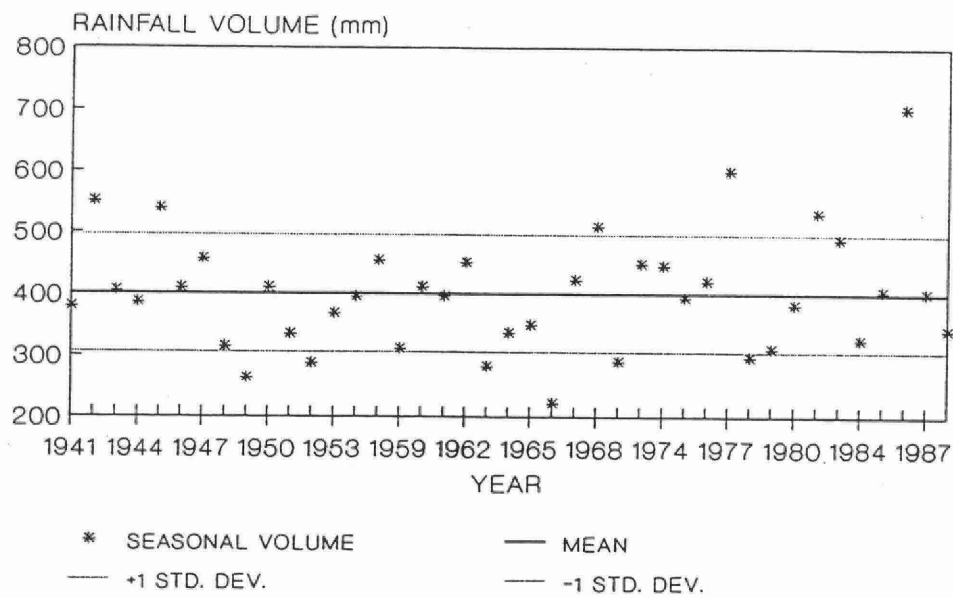
ELLESMERE STATION
SUMMER/FALL RAINFALL
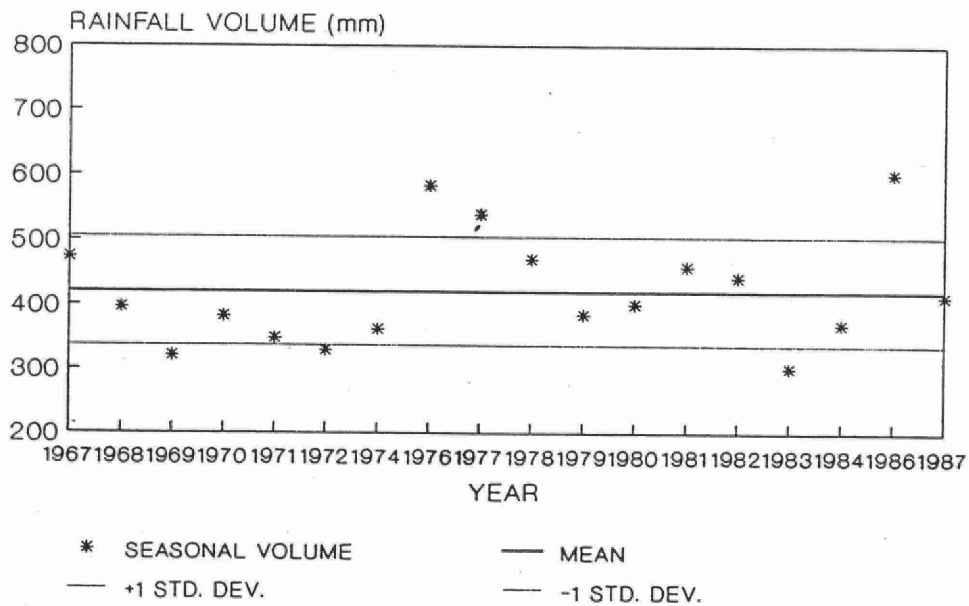
BASED ON MAY TO OCTOBER RAINFALL

TABLE 3.2:　　　　　　　AVERAGE AND TYPICAL YEAR RANINFALL CHARACTERISTICS FOR MAY TO OCTOBER

| | Annual Volume (mm) | S.D.[1] | Event Volume (mm) | S.D. | Event[3] Duration (Hours) | S.D. | Event[3] Intensity (mm/hr) | S.D. | Number of Events | S.D. |
|---|---|---|---|---|---|---|---|---|---|---|
| **Historical Average** | | | | | | | | | | |
| Toronto Bloor[2] | 400 | 104 | 7.25 | 1.4 | 5.75 | 0.74 | 1.34 | 0.26 | 59 | 7 |
| Ellesmere[2] Scarborough | 421 | 84 | 6.9 | 1.0 | 5.71 | 0.88 | 1.36 | 0.25 | 51 | 8 |
| **Typical Year 1980** | | | | | | | | | | |
| Toronto Bloor | 384 | | 5.8 | | 5.06 | | 1.12 | | 66 | |
| Ellesmere Scarborough | 401 | | 6.7 | | 5.32 | | 1.39 | | 60 | |

1　S.D.　=　Standard Deviation

2　Bloor Station based on 42 years of useable records.　Ellesmere station based on 18 years of useable records.

3　Based on hourly rainfall data and an inter-event period of 6 hours.

**1980 RAINFALL EVENT VOLUME SUMMARY**
**(MAY TO OCTOBER)**
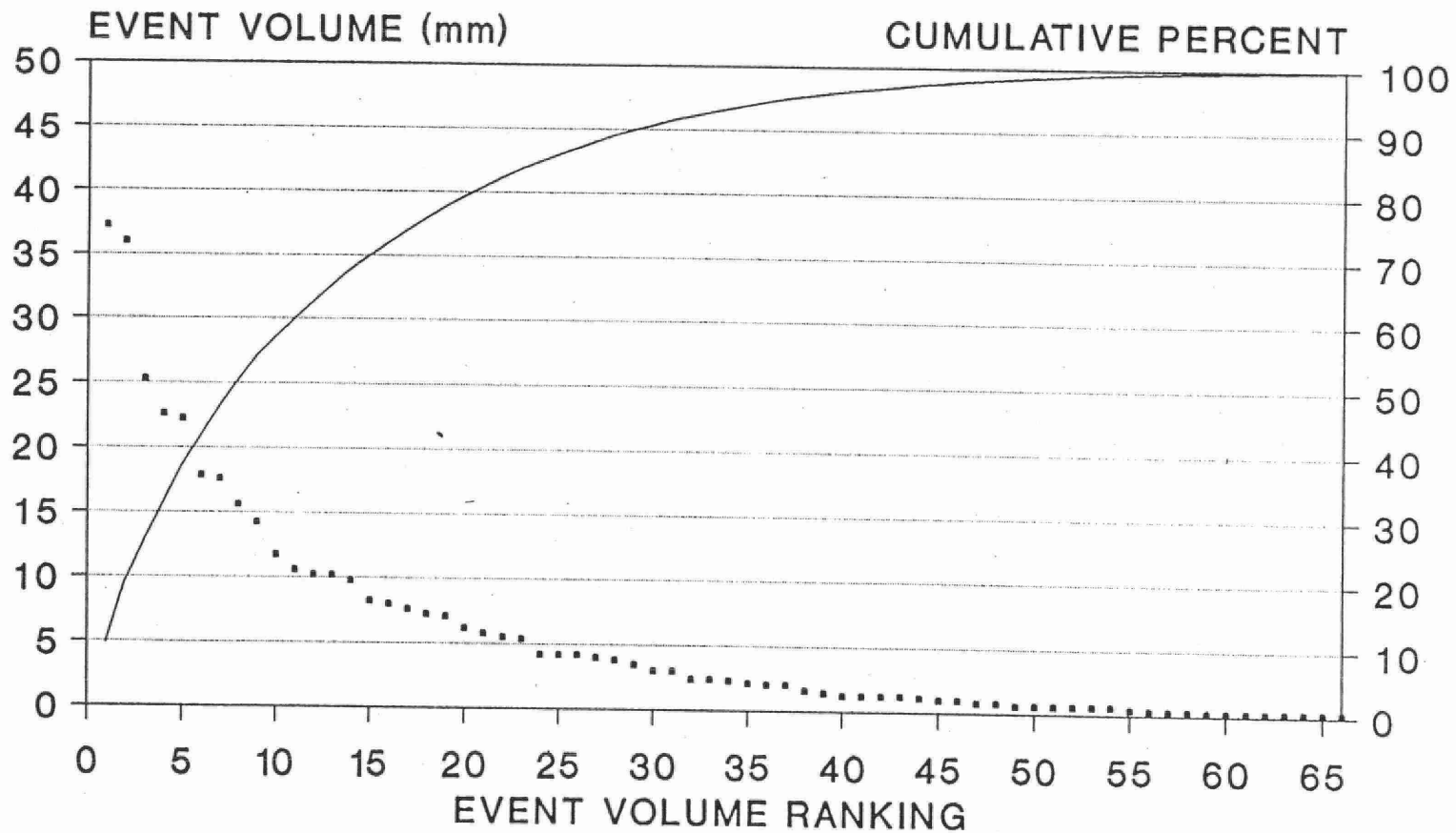
BASED ON AN INTEREVENT PERIOD OF 6 HOURS

FIGURE 3-2

AVERAGE PRECIPITATION DISTRIBUTION BY MONTH
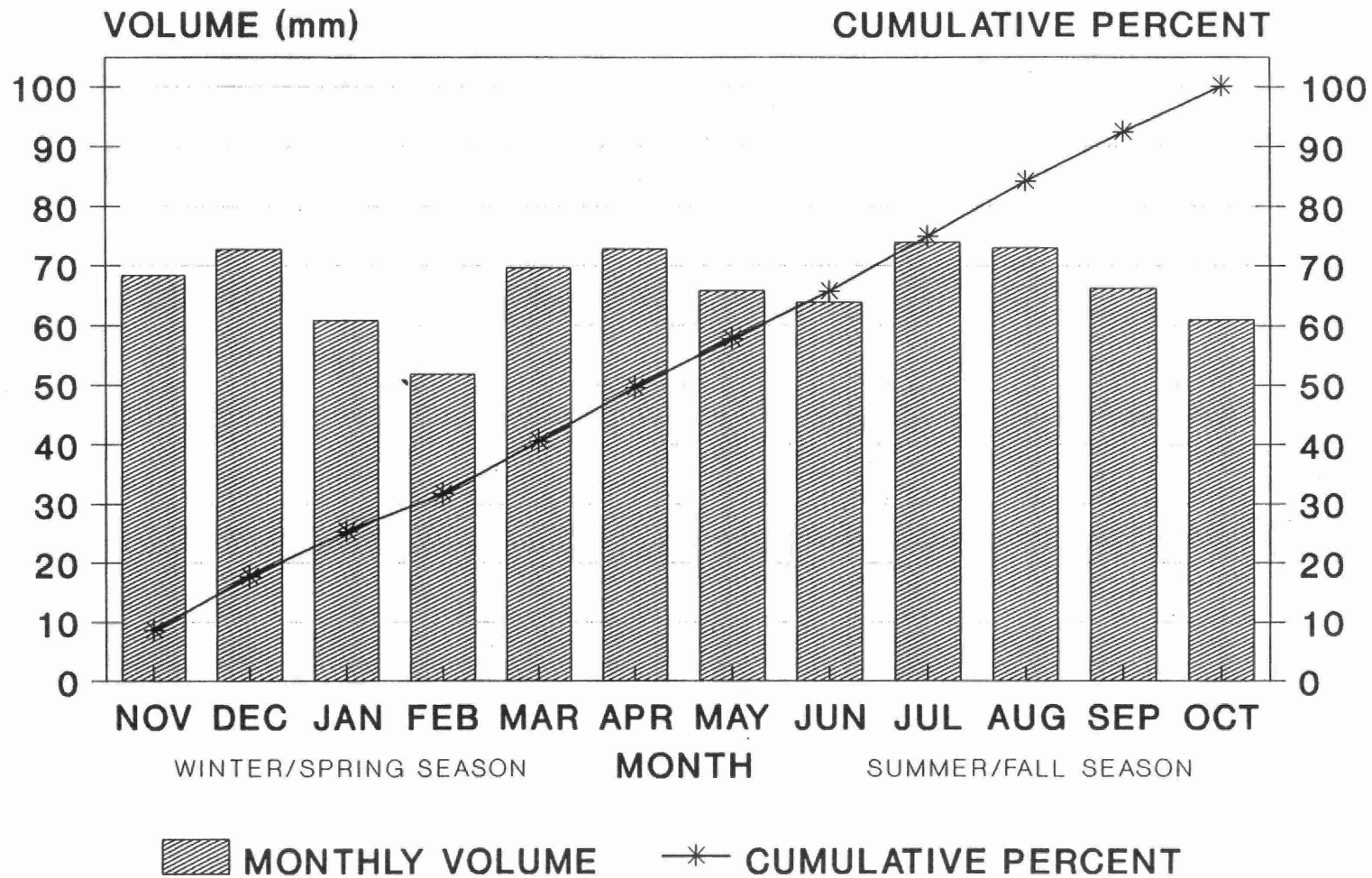
Figure 3·3

AES TORONTO (BLOOR) RAIN GAUGE

this study. The approach used to estimate discharge volumes for outfalls discharging CSOs is discussed in Section 3.3.

This computer program has two modes of operation, event and continuous simulation. The event mode analyzes rainfall and runoff for short durations, usually for a single event. Incorporating the effects of a series of actual rainfall events for a given period of time and the hydrological processes such as infiltration and evaporation between these rainfall events requires simulation on a continuous basis. This approach was used in this study.

The SWMM program is a deterministic modelling tool, that is to say, if the hydrologic input data are representative of the study area, the model will closely simulate the runoff response of the catchments.

The hydrologic input parameters required for the model are:

- rainfall;
- catchment area;
- catchment slope;
- percent of impervious area in the catchment;
- catchment width;
- infiltration characteristics of pervious areas; and
- depression storage for pervious and impervious areas.

The most sensitive parameters for predicting runoff volumes are the rainfall rate, catchment area and percent imperviousness. Infiltration rates and antecedent conditions are important parameters for continuous simulation, particularly for small events. Many of the other parameters affect the rate of runoff. The time step selected for analysis was 1 hour. This time step was considered adequate for the purpose of estimating runoff volume.

Model setup required the delineation of catchments for all sewered and unsewered areas discharging to the waterfront, see Figure 3.4. The catchment areas were delineated using municipal sewer maps and transferred to one to ten thousand Ontario Base Maps (OBM). The catchment areas were determined by digitizing these maps with CADD software. Land use maps for Etobicoke and Scarborough were used to determine land uses for each catchment. Adjacent catchments with similar characteristics were lumped together to reduce the number of catchments for analysis. In Etobicoke, 23 catchments were reduced to 12 (Catchments E1 to E12). In Scarborough, 21 catchments were

TOWN OF VAUGHAN    TOWN OF MARKHAM

NORTH YORK

SCARBOROUGH

ETOBICOKE    YORK

EAST YORK

CITY
OF
TORONTO

LAKE   ONTARIO

MUNICIPALITIES OF
METROPOLITAN TORONTO

SCARBOROUGH

S15
S13    S16
S18    S14
S17
S12
S10    S11
S9
S8
S7
S5
S4    S6
S3
S1    S2

TORONTO

LAKE   ONTARIO

Scarborough Bluffs

ETOBICOKE

Humber

Grenadier
Pond

HUMBER BAY

ONTARIO
PLACE

TORONTO
ISLAND
AIRPORT

TORONTO
INNER
HARBOUR

TORONTO
OUTER
HARBOUR

TORONTO
ISLANDS

Keating Channel

E12
E11
E10
E9
E8
E7
E6
E5
E1    E2    E3

LAKE   ONTARIO

BLOOR STREET WEST
QUEEN ELIZABETH WAY
THE QUEENSWAY
BLOOR STREET
QUEEN STREET W.
KING STREET
LAKESHORE BLVD.

reduced to 18 (catchments S1 to S18). A summary of the catchments and their land uses is listed in Tables 1.1 and 1.2.

Initial estimates of the percent impervious parameter for each subcatchment were based on land use characteristics, literature data and field observations. Infiltration rates were derived from predominate soil types. In Etobicoke and Scarborough, the predominate soil types are clay loam and sandy loam, respectively. A list of input parameters is presented in Table 3.3.

A simplified approach was used to predict runoff volumes for the winter/spring season. The uncertainties associated with estimating values for variables such as type of precipitation (i.e., rain or snow), precipitation volume, snowmelt rate, volume of snow removed, infiltration rates for frozen/partially frozen conditions, etc., would result in a large degree of uncertainty precluded estimating winter/spring volumes using a detailed modelling approach. The approach used is discussed in Section 3.4.

### 3.3    Estimates of Summer/Fall CSO Volumes

Six outfalls with TAWMS outfall numbers 914, 912, 910, 908, 906 and 904 in the City of Scarborough and labelled S1 to S6 in this study were excluded from the above-mentioned modelling approach. These outfalls receive runoff from a mix of combined and storm sewer systems. A small number of these catchments are serviced by the original combined sewer system where, in many cases, roof, road and pervious area runoff combines with domestic sewage for treatment at the Metro Main Sewage Treatment Plant. A large portion of each catchment area however has been separated with runoff from roads and pervious areas now serviced by a separate storm sewer system.

Several interconnections exist between the two sewer systems primarily to provide flow control to the sewage treatment plant and for flood relief measures. The quantities and frequency of overflow are dependent on the overflow structure and the rainfall event. Furthermore, some combined sewage will be sent to the sewage treatment plant and other combined sewage may overflow internally into an adjacent catchment. As such, the quantities of runoff discharged by each outfall is not simply that quantity which may be generated within its own catchment area.

To estimate the volume of discharge from this type of complex network requires detailed hydraulic analysis of overflows and the sewer network. Detailed modelling using the U.S. EPA SWMM Runoff and Extran Blocks on these catchment areas, pipes and overflows and continuous long-term

## TABLE 3.3: SWMM HYDROLOGIC AND CATCHMENT INPUT PARAMETERS

| | | | |
|---|---|---|---|
| Imperviousness | • | Residential (%)* | 35.0 |
| | • | Commercial (%)* | 90.0 |
| | • | Industrial (%) | 90.0 |
| | • | Institutional (%) | 70.0 |
| | • | Open (%) | 5.0 |
| Ground Slope (%) | | | 2.0 |
| Depression Storage | • | Imperviousness (mm) | 1.5 |
| | • | Pervious (mm) | 4.0 |
| Infiltration | • | Initial (mm/hr) | 40.0 |
| | • | Final (mm/hr) | 4.0 |
| | • | Decay (L/hr) | 0.00115 |

* Calibrated values (see Section 3.6)

simulation using the Storage Treatment Overflow Runoff Model (STORM) was carried out previously (Proctor and Redfern, 1988). The detailed modelling exercise predicted annual runoff volumes for each outfall. The previous study reported annual runoff and CSO volumes, but the estimates were only calculated for events recorded between April and November for the year 1960 to 1983 (Cheung P., personal communication).

The level of detail in the study carried out by Proctor & Redfern was considered adequate for the objectives of this present study. The volumes, however, required adjustment to conditions representative of the selected typical year and seasonal periods. The adjustments were prepared by prorating CSO volumes estimated in the previous study using total rainfall. The CSO estimates presented in the previous study were based on 67 percent of the annual rainfall depth. This study is preparing estimates based on 48 percent of the annual rainfall for the summer/fall season. Therefore, the CSO volumes presented in this report are 72 (48/67) percent of the estimates prepared in the previous study.

### 3.4     Estimation of Winter/Spring Wet Weather Runoff Volumes

For the period of November to April, a simplified method for the estimation of wet weather runoff volume was used. The method used was based on a mass balance approach in which the summer/fall seasonal runoff volume was adjusted by an appropriate volumetric snowmelt runoff coefficient.

A review of current literature indicated that there are only a limited number of studies which have computed snowmelt runoff volumes in urban areas within Ontario. One report which summarized the field investigations carried out in Peterborough, Ontario (Buttle and Xu, 1988) provided the following information for 5 melt periods in 1984 and 1985. The measured response of runoff volume to available precipitation (volumetric runoff coefficient) in a suburban area varied from 45 to 94 percent. The average response or volumetric runoff coefficient was 60 percent. By comparison, the volumetric runoff coefficient for urban areas during summer and fall conditions in Toronto is about 30 percent based on average imperviousness of 35 percent (Environment Ontario, 1989). These data suggest that the winter/spring season may generate approximately 2 times as much runoff compared to the summer/fall season. The primary cause for the increase in runoff volume is saturated and frozen ground conditions which minimize losses due to infiltration and evaporation.

In an attempt to substantiate these observations, historical flow data for 5 tributaries (Etobicoke Creek, Humber River, Don River, Highland Creek and Rouge River) flowing to the Toronto waterfront were

analyzed. The cumulative percent of flow volume was calculated for each tributary from average monthly data available from Water Survey of Canada. The means for each month were calculated and are illustrated in Figure 3.5. The average precipitation for the two seasonal periods is about equal. This was shown in Section 3.1. The data in Figure 3.5 shows that 60 to 70 percent or approximately two thirds of the annual flow volume occurs between the months of November and April. Thus, this analysis also suggests that the winter/spring period may generate approximately 2 times as much runoff volume as the summer/fall period.

Accordingly, for the purposes of this study, the winter/spring runoff volumes were estimated by doubling the summer/fall runoff volumes predicted by the computer simulating modelling.

## 3.5    Urban Runoff Measurements

Summarized in Table 3.4 are the volumes of runoff measured at each site for the duration of monitoring (10 October to 27 November 1989). A sample of the observed flows at the Brooklawn site is presented in Figure 3.6. The plot shows the wide range of flow durations, peak rates, volumes and inter-event periods recorded during the monitoring period.

During the 10 October to 27 November 1989 period, 20 precipitation events occurred. The rainfall volume in this period was in excess of normal conditions (approximately 2 times greater). Rainfall records were obtained from the AES Bloor station until it was closed (for the winter period) at the end of October at which time the City of Toronto Swansea Station was used. On average, 18 events were monitored at nine storm sewer sites (equipment malfunctioning did not permit measurements to be recorded for all events). The size of rainfall events monitored with measurable flows ranged from 1 mm to 26 mm (see Table 3.4). For all stations, except Stations 3, 8 and 9, very little to no baseflow was observed.

The wetter than normal rainfall conditions and the relatively short monitoring period (7 weeks) presents some limitations with respect to the validity of using the data collected during the fall to predict annual loadings. To address this issue an additional study (M. D'Andrea, 1992) to monitor stormwater runoff quality and quantity at two locations during winter, spring and summer conditions is in progress. The ongoing study will validate the assumptions made in this study.

# ANNUAL WATERSHED FLOW VOLUMES



CUMULATIVE VOLUME (percent)

Legend:
- ETOBICOKE CR
- HIGHLAND CR
- HUMBER R
- ROUGE R
- DON R
- AVERAGE

MONTH

WINTER/SPRING — SUMMER/FALL

Months: NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT

FIGURE 3·5
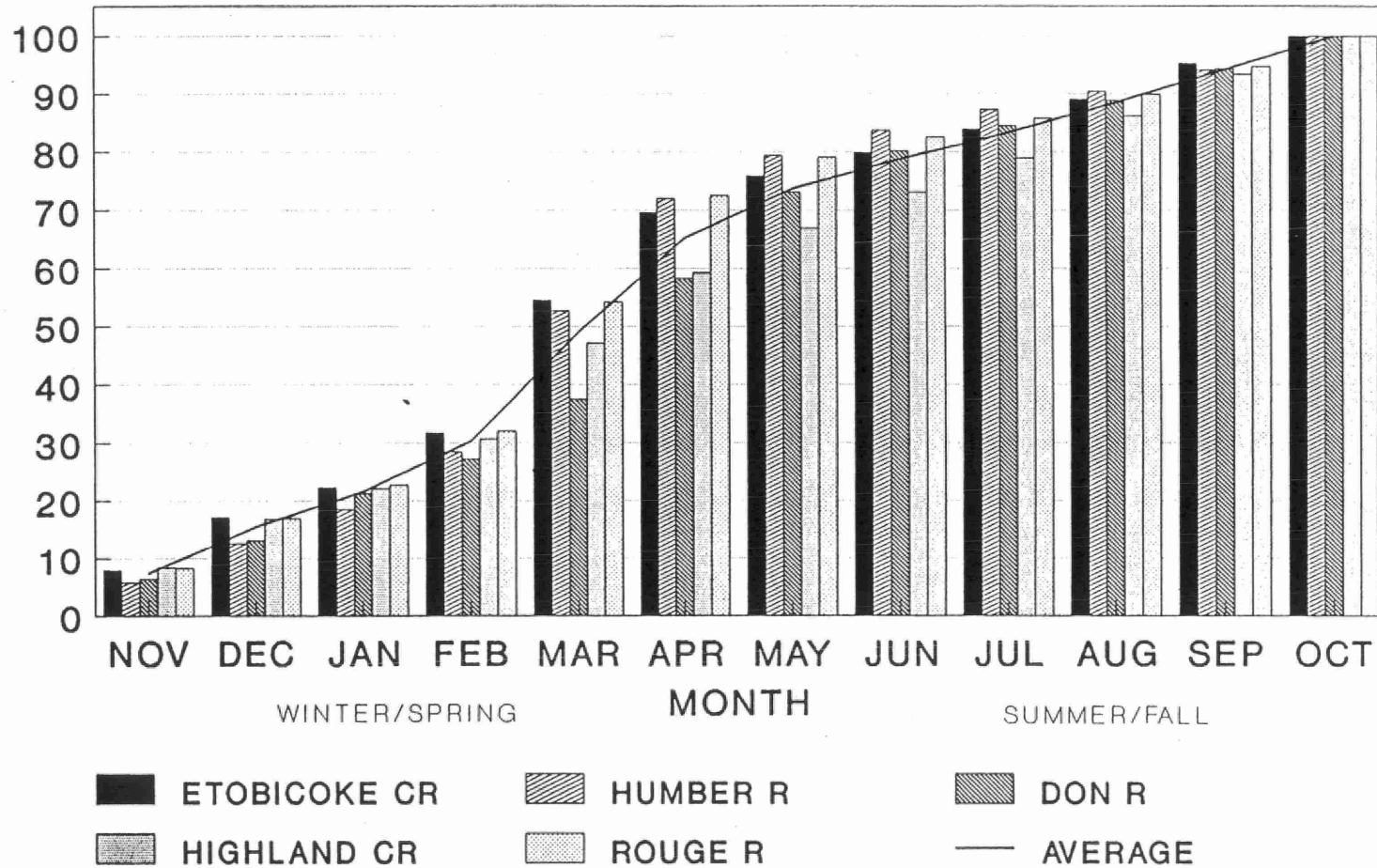
## TABLE 3.4 Monitored Event Volume Summary

MEASURED VOLUME (cubic meters) by event

| MONITORING SITE No. | MONITORING LOCATION | Oct 10 | 16 | 17 | 19 | 21 | 31 | Nov 2 | 5 | 7 | 8 | 9 | 10 | 11 | 14 | 15 | 18 | 19 | 20 | 26 | 27 | NUMBER OF MEASURED EVENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BLOOR & SWANSEA n1 | Precipitation Depth (mm) | 9.6 | 12.2 | 10.4 | 26.20 | 7.80 | 16.00 | 1.50 | 4.75 | 16.25 | 2.00 | 6.25 | 0.50 | 2.00 | 15.25 | 12.75 | 1.00 | 0.25 | 3.50 | 1.50 | 8.75 | |
| 1 | Main STP Bypass | <<<- ------ ------ bypass ------ bypass NO FLOW MEASUREMENTS ------- -------- ------ bypass bypass ------ ------ ------ ------ -->>> | | | | | | | | | | | | | | | | | | | | 0 |
| 2 | Berry St. CSO | <<<- ------ ------ ------ ------ ------ NO CSO OCCURRENCES ------- -------- ------ ------ ------ ------ ------ ------ ------ -->>> | | | | | | | | | | | | | | | | | | | | 0 |
| 3 | L308 | 3600 | 1600 | 3800 | 9600 | 1700 | 3600 | 600 | 2400 | 9400 | 3200 | 2700 | 1400 | 2100 | 17300 | n2 | 250 | n4 | 1300 | 400 | 3400 | 18 |
| 4 | L102 | 50 | 50 | 150 | 500 | 50 | 150 | 0 | 100 | 300 | 100 | 100 | 0 | 50 | 700 | n2 | 0 | 0 | 100 | 50 | 200 | 19 |
| 5 | Browns Line | 6500 | n3 | n3 | 7400 | 2100 | 3600 | 400 | 1100 | 4500 | 1300 | 1200 | 900 | 300 | 10500 | n2 | 400 | 250 | 1500 | 200 | 2200 | 17 |
| 6 | Kingston Road 1 | n3 | n3 | n3 | n3 | 150 | n3 | 200 | n4 | 250 | 50 | 100 | n3 | n3 | 900 | 50 | n4 | 250 | n3 | 0 | 150 | 10 |
| 7 | Cecil CSO | n3 | 1600 | 800 | 2600 | 600 | 800 | 500 | 600 | 1300 | 1300 | 800 | 80 | 200 | 3147 | n2 | 110 | 22 | 652 | 64 | 1064 | 18 |
| 8 | E11 | n3 | n3 | n3 | n3 | n3 | 5000 | 1800 | 2800 | 5800 | 2200 | 2800 | n3 | n3 | 6700 | 500 | n3 | n4 | 1400 | 800 | 4000 | 11 |
| 9 | Beachgrove | n3 | n3 | n3 | n3 | n3 | 1300 | 299 | 1000 | 5000 | 2900 | 3700 | 0 | 50 | 3600 | n2 | 150 | 150 | 4300 | 100 | 4900 | 13 |
| 10 | Kingston Road 2 | n3 | n3 | n3 | 0 | 150 | 700 | 600 | 700 | 1100 | 300 | 600 | 50 | 150 | 2600 | n2 | 50 | 0 | 600 | 50 | 700 | 15 |
| 11 | Brooklawn | n3 | n3 | n3 | 5000 | 1400 | 1600 | 1100 | 1100 | 2600 | 1100 | 150 | 300 | 400 | 5900 | n2 | 250 | 150 | 1500 | 100 | n4 | 15 |

NOTES:
n1. PRECIPITATION DATA FOR OCTOBER FROM BLOOR STATION, FOR NOVEMBER FROM SWANSEA STATION

n2. EVENT OF NOVEMBER 15, 1989 IS INCLUDED IN NOVEMBER 14, 1989

n3. NO DATA AVAILABLE

n4. POOR DATA, STORM EVENT CANNOT BE SEPARATED FROM BASE FLOW

# SAMPLE OF OBSERVED FLOW
## SITE 11 BROOKLAWN

FLOW (l/s)

TIME (days)

—— MONITORED FLOW
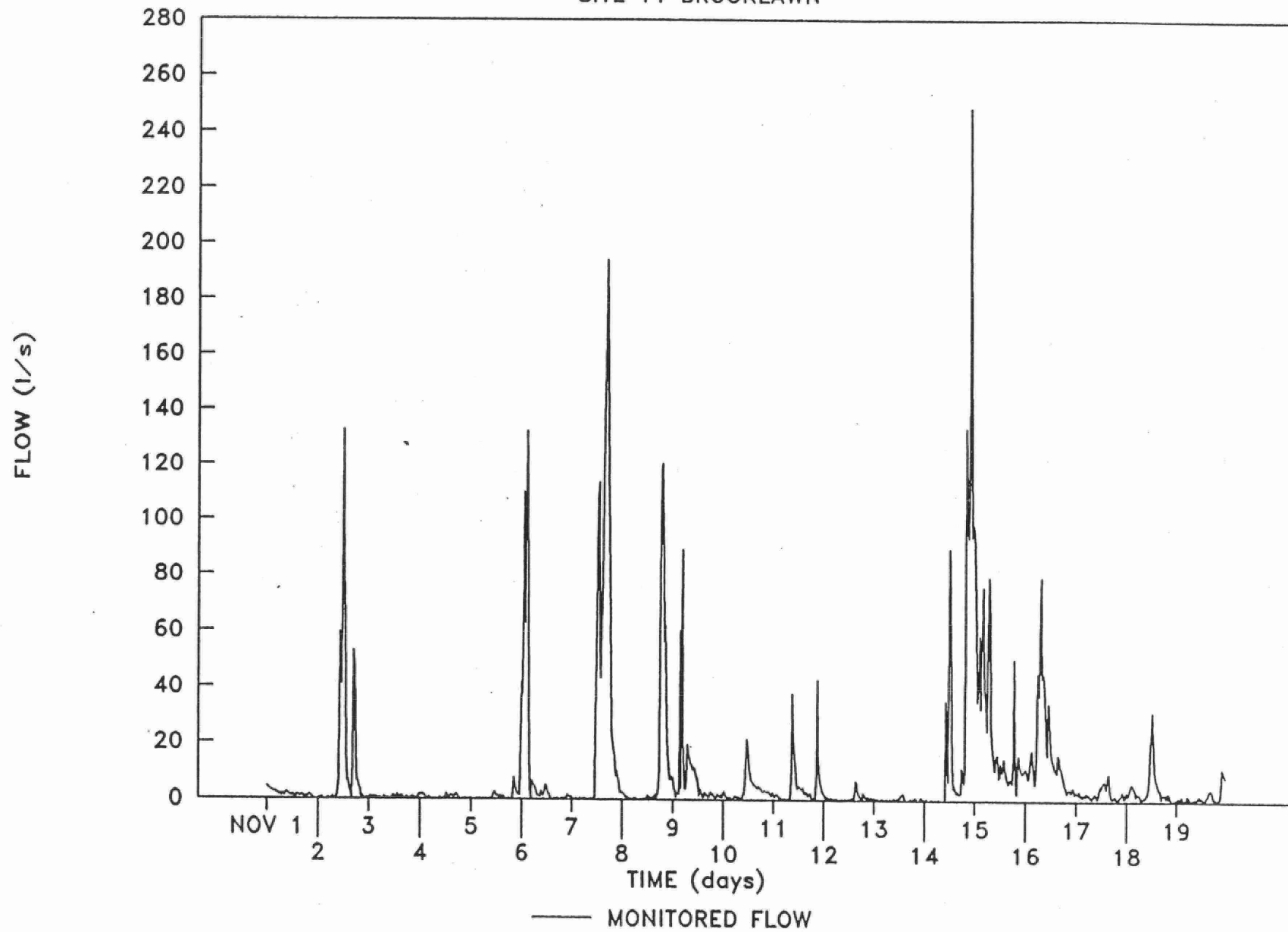
FIGURE 3·6

The accuracy of these flow measurements is a function of site specific hydraulic conditions, the procedure used to calibrate the equipment, the quality of installation and instrumentation, and the frequency of site maintenance. For practical and safety reasons, detailed cross-checks of installed flow meter readings during wet weather conditions was not possible. The flow depths and velocities were however checked periodically at each site, using physical measurements to estimate depth and a portable velocity meter to estimate velocity, and the flow meters calibrated accordingly. The accuracy of each instrument is a function of flow depth and velocity, with greater inaccuracy occurring for shallower depths of flow. Based on average flow and installation conditions and previous experience, instrumentation errors of approximately ±5 percent were assumed.

## 3.6     Runoff Model Calibration

Calibration of a computer model is generally carried out by varying the input parameters until a reasonable agreement between the observed and predicted values is achieved. In this study, the primary parameter (or output value) to which the model will be calibrated is the runoff volume. Outlined below is the methodology used to calibrate the SWMM model.

The calibration was carried out for the 31 October to 29 November 1989 period. This period was selected as flow monitoring information was available. Furthermore, a wide range of precipitation volumes occurred during this period.

Key parameters which affect the estimation of runoff volume and require adjustment in order to calibrate the model include rainfall data, drainage area, percent imperviousness, depression storage, infiltration rates and evaporation rates. Each of these parameters were considered in the calibration process, however, the most sensitive parameter was found to be the percent imperviousness. In addition, this parameter varies considerably between catchment areas.

Data from three monitoring sites, Brooklawn, a residential/institutional area; Kingston Road 2, a residential/commercial area; and Cecil, a residential site with CSO, were selected as representative locations for model calibration.

Keeping all unchanged to the initial setup, the required percent imperviousness for these sites were as follows:

-     Brooklawn  -  44 percent;
-     Kingston Road 2  -  50 percent; and
-     Cecil CSO  -  10 percent.

The relatively low value for the Cecil CSO site compared to other sites is due to runoff (likely from roofs) being transported by the combined sewer system with the catchment.

Considering the land use distributions for the Brooklawn and Kingston Road 2 sites, the percent imperviousness for residential areas was determined to be 35 percent for residential and 90 percent for commercial. Hence, these levels of imperviousness were used for unmonitored catchments containing these land uses. These results were found to be relatively consistent with the literature data initially used to set up the model.

Results of the calibration are presented in Figure 3.7. The results, in general, show good agreement between the predicted and observed flow volumes.

### 3.7     Flow Volume Estimates

Flow volumes were estimated for each catchment area within the study area. The estimates were established on a seasonal basis (summer/fall and winter/spring) for a typical year of rainfall (1980). The calibrated continuous simulation model was used to predict runoff volumes for the summer/fall season. A simplified method based on a volumetric runoff coefficient and a ratio between summer/fall runoff volumes and winter/spring volumes was used to predict the winter/spring seasonal volumes. Table 3.5 presents seasonal and annual volumetric discharge predictions ranked largest to smallest for each modelled catchment. Table 3.6 presents total seasonal and total annual volumetric discharge predictions by municipality.

The total estimated average annual volume of discharge from the Etobicoke and Scarborough waterfront catchments is 13.7 million cubic metres. Approximately 15 percent of this volume (2.1 million cubic metres) contains some quantity of CSO. For the period May to October (summer/fall) and November to April (winter/spring), the total waterfront wet weather discharge from sewer outfalls are 4.58 and 9.16 million cubic metres, respectively.

FIGURE 3·7

STATION 7 CECIL CSO
RESIDENTIAL LAND USE

CUMULATIVE RUNOFF VOLUME (Thousand m^3)

— OBSERVED    + SIMULATED
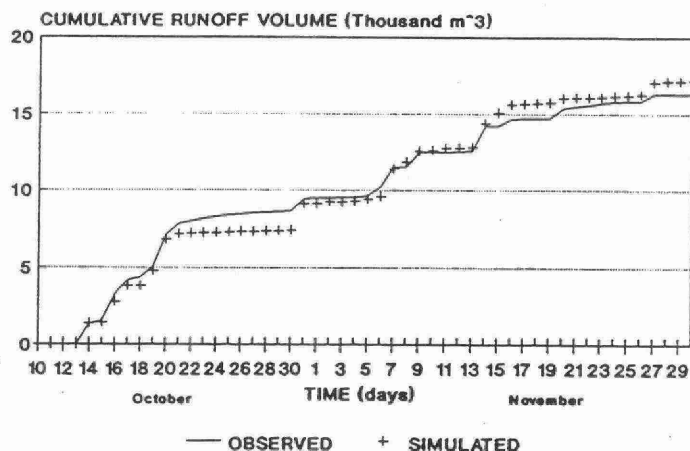
STATION 11 BROOKLAWN
RESIDENTIAL LAND USE

CUMULATIVE RUNOFF VOLUME (Thousand m^3)

— OBSERVED    + SIMULATED
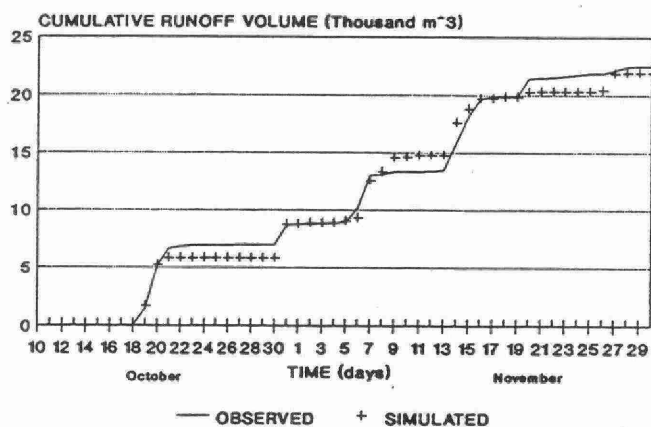
STATION 10 KINGSTON RD 2
RESIDENTIAL/COMMERCIAL LAND USE

CUMULATIVE RUNOFF VOLUME (Thousand m^3)

no data

— OBSERVED    + SIMULATED
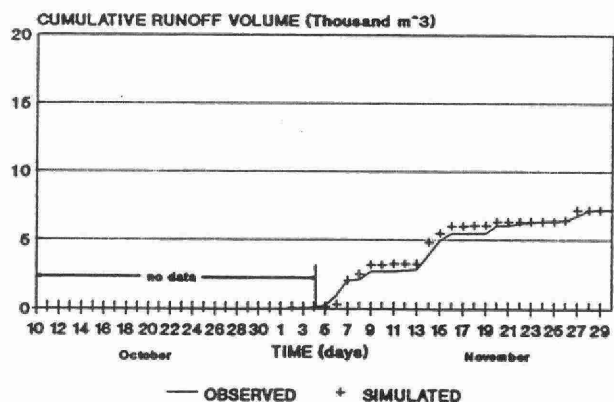
# CALIBRATION RESULTS FOR 3 MONITORING STATIONS

**TABLE 3.5**   **PREDICTED SUMMER/FALL AND ESTIMATED WINTER/SPRING WATERFRONT RUNOFF VOLUMES BY MODELLED CATCHMENT**

| CATCHMENT | SUMMER/FALL (cubic meters) | WINTER/SPRING (cubic meters) | PERCENT OF TOTAL |
|---|---|---|---|
| E5 | 879,000 | 1,758,000 | 19.2 |
| E10 | 374,000 | 748,000 | 8.2 |
| E8 | 317,000 | 634,000 | 6.9 |
| S18 | 311,000 | 622,000 | 6.8 |
| S6* | 268,200 | 536,400 | 5.9 |
| S10 | 252,000 | 504,000 | 5.5 |
| S12 | 181,000 | 362,000 | 4.0 |
| S7 | 165,000 | 330,000 | 3.6 |
| E4 | 160,300 | 320,600 | 3.5 |
| S9 | 160,000 | 320,000 | 3.5 |
| S4* | 148,200 | 296,400 | 3.2 |
| S8 | 137,000 | 274,000 | 3.0 |
| S11 | 126,000 | 252,000 | 2.8 |
| S2* | 121,000 | 242,000 | 2.6 |
| S13 | 106,000 | 212,000 | 2.3 |
| S16 | 100,000 | 200,000 | 2.2 |
| S17 | 98,700 | 197,400 | 2.2 |
| E11 | 88,400 | 176,800 | 1.9 |
| E9 | 75,600 | 151,200 | 1.7 |
| S14 | 75,300 | 150,600 | 1.6 |
| S15 | 71,800 | 143,600 | 1.6 |
| S5* | 70,900 | 141,800 | 1.5 |
| E7 | 67,300 | 134,600 | 1.5 |
| S1* | 59,200 | 118,400 | 1.3 |
| S3* | 51,000 | 102,000 | 1.1 |
| E12 | 30,000 | 60,000 | 0.7 |
| E1 | 28,600 | 57,200 | 0.6 |
| E3 | 26,000 | 52,000 | 0.6 |
| E2 | 17,300 | 34,600 | 0.4 |
| E6 | 13,500 | 27,000 | 0.3 |
| **TOTAL** | **4,579,300** | **9,158,600** | **100.0** |

ANNUAL WATERFRONT TOTAL (cubic meters)          13,700,000
(excluding City of Toronto)

* Catchment contains CSO

## TABLE 3.6    ESTIMATED WATERFRONT RUNOFF VOLUMES
## SEASONAL AND ANNUAL SUMMARY

| WATERFRONT | SUMMER/FALL (cubic meters) | WINTER/SPRING (cubic meters) | ANNUAL (cubic meters) |
|---|---|---|---|
| ETOBICOKE | 2,077,000 | 4,154,000 | 6,231,000 |
| SCARBOROUGH * | 2,502,300 | 5,004,600 | 7,506,900 |
| catchments with CSO (S1 to S6) | (718,500) | (1,437,000) | (2,155,500) |
| **ANNUAL WATERFRONT TOTAL (cubic metres)** (excluding City of Toronto) | | | **13,700,000** |

* INCLUDES CATCHMENTS WHICH CONTAIN CSO

The annual discharge volumes between the two municipalities are about equal. Although the Scarborough waterfront has a catchment area 1.7 times greater than the Etobicoke waterfront area, the Etobicoke catchments generate a larger unit volume of runoff due to the higher level of imperviousness (52 percent versus 30 percent). The higher level of impervious area is attributable to the lower level of open space areas within Etobicoke as well as the larger percentage of industrial areas (see Table 1.3).

The distribution of runoff event volumes for the summer/fall season will vary based on the precipitation patterns (see Figure 3.2). The modelling results show that approximately 50 percent of the summer/fall seasonal runoff is generated by the six largest rainfall events which range from 18 to 37 mm. A summary of the total discharge to the waterfront and the relative contributions for each of the six events to the total seasonal volume is presented in Table 3.7. Detailed listing of the volume for each catchment by each event is provided in Appendix 2.

The single largest catchment area, E5, in Etobicoke discharges 19 percent of the total annual volume of urban runoff to the waterfront through 3 sewer outfalls, L203B, L204 and L205. L204 is the dominant of the three outfalls, representing 91 percent of this catchment area. The catchment area for outfall L204 is the largest in the study area at 380 ha (this represents approximately 10 percent of the study area) and has a high degree of imperviousness. The next single largest outfall, E10, contributes 8 percent of the runoff volume.

Fifty percent of the total annual runoff volume originates from 6 catchments (i.e., E5, E10, E8, S18, S6 and S10). Runoff from these catchments is discharged through 7 of 46 outfalls (15 percent) along the Etobicoke and Scarborough waterfront.

Calibration of the model should ensure that the predicted runoff volumes are reasonable. However, any estimate of this type is subject to a degree of uncertainty, especially for the unmonitored catchments. Several factors may result in inaccurate estimates. For example, errors may exist in the delineation and digitizing of the catchment areas. Furthermore, although the model is calibrated, there is still a significant amount of variability which cannot be accounted for in defining several of the parameters including precipitation volumes, percent imperviousness and infiltration rates.

In order to estimate the degree of uncertainty in the runoff volumes as stated above, an error analysis was performed. Each of the key input parameters was varied to determine the impact on flow volume predictions. The upper and lower limits for each parameter used in this analysis (Table A.1) and the

TABLE 3.7:        RUNOFF VOLUMES GENERATED BY THE SEVEN LARGEST RUNOFF EVENTS DURING SUMMER/FALL PERIOD

| Event | Rainfall Depth (mm) | Total Discharge Volume to the Waterfront ($m^3$) | Fraction of Seasonal Runoff Volume (%) | Cumulative Volume (%) |
|---|---|---|---|---|
| 1 | 37.2 | 574,000 | 14 | 14 |
| 2 | 36.0 | 458,000 | 11 | 25 |
| 3 | 35.3 | 311,234 | 7 | 32 |
| 4 | 22.2 | 281,000 | 7 | 39 |
| 5 | 22.6 | 272,000 | 6 | 45 |
| 6 | 17.8 | 235,000 | 6 | 51 |

associated predicted flow volumes (Table A.2) are provided in Appendix 2. The results of the error analysis for the typical rainfall year indicates that the volume of runoff discharging to the waterfront ranges between 53 to 134 percent of the predicted volume.

## 3.8    Main Water Pollution Control Plant Bypass Volume

Limited information is available on the quality and quantity of primary effluent bypass from the Main WPCP during rainfall events. An attempt was made in this study to sample and quantify the volume of Main WPCP bypass. A few water quality samples were collected, however, monitoring of flows was not possible due to hydraulic, structural and instrumentation constraints.

Bypass volumes, based on bypass durations are, however, estimated by plant operators. A summary of the 1989 bypass incidents and estimated volumes provided by the Metro Toronto Works Department is presented in Table 3.8. Excluding occurrences as a result of construction activities, bypassing of flows occurred 16 times in 1989. The duration of bypassing ranged from 0.5 to 10.0 hours. The average bypass volume was 43,000 cubic metres and the total annual volume was 687,500 cubic metres.

The occurrence and volume of bypassing is directly related to rainfall conditions. Therefore, a direct comparison of 1989 bypass volumes to sewer outfall volumes in 1980 is limited to establishing relative contributions within an order of magnitude. The total annual volume bypassed represents approximately 5 percent of the annual runoff volume discharged via waterfront outfalls within the Cities of Etobicoke and Scarborough (see Section 3.7). It is not known how typical the bypass conditions are with respect to the long-term averages as bypassing may have been affected by the ongoing plant maintenance and upgrading. These bypass volumes however were used to estimate annual bypass loadings.

The main WPCP services a sewerage area of 26,570 ha. This area is approximately seven times greater than the Etobicoke and Scarborough waterfront drainage area.

TABLE 3.8:     SUMMARY OF MAIN WPCP BYPASSING FOR 1989

| Date | Duration (Hours) | Estimated Quantity (x 1,000 m$^3$) |
|------|------------------|-------------------------------------|
| 04 April | 3.0 | 25.0 |
| 05 May | 3.0 | 26.3 |
| 30 May | 2.0 | 17.5 |
| 02 June | 5.5 | 45.8 |
| 08 June | 4.0 | 41.7 |
| 27 July | 2.0 | 16.2 |
| 04 August | 1.0 | 8.1 |
| 16 August | 10.0 | 110.0 |
| 14 September | 1.0 | 8.1 |
| 23 September | 4.5 | 104.9 |
| 14 October | 2.5 | 28.6 |
| 20 October | 4.8 | 46.0 |
| 31 October | 3.0 | 33.0 |
| 07 November | 4.5 | 59.0 |
| 14 November | 0.5 | 33.7 |
| 15 November | 4.8 | 83.6 |
| Total | | 687.5 |

# 4 – CONTAMINANT CONCENTRATION ESTIMATES

## 4.1 Field Program Summary

The objective of the field program was to measure flow volumes and constituent concentrations at eleven monitoring stations. This data would then be used as a basis to characterize loadings for a wide variety of contaminants to the Etobicoke and Scarborough waterfronts. The list of sites and their locations were presented in Table 2.1.

In order to provide a reasonable measure of variability, the target number of samples to be collected per site was eight. Table 4.1 lists the number of samples collected at each location. Of the targeted goal of 88 samples (8 samples from 11 sites), a total of 65 were obtained (see Table 4.1). The major reasons why fewer samples were collected include:

– no occurrences of an overflow at the Berry Street Overflow and only limited bypassing at the Main WPCP;

– insufficient sample volume collected for some events due to the size of the event and interference and/or malfunctioning of equipment. If less than 16 litres was collected, the analysis of organics was not possible; and/or

– insufficient duration for monitoring prior to winter conditions setting in.

The seven week monitoring period in the month of October and November had a total rainfall volume in excess of the long term normal conditions for this time period. The monitoring duration, the wetter than normal conditions and the limited seasonal conditions may affect the concentration and presence of some contaminants is stormwater runoff. To address this issue an additional study (M. D'Andrea, 1992) to monitor stormwater runoff quality and quantity at two locations for winter, spring and summer conditions is underway. This ongoing study will validate the assumptions in this study.

TABLE 4.1:    SUMMARY OF PARAMETER CODES, FREQUENCY OF DETECTION AND DETECTION LIMIT VALUES FOR THE WHOLE DATA SET

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **General Chemistry** | | | | | | |
| Alkalinity (as CaCO₃) | ALKT | 0.02 | mg/L | 56 | 56 | 100 |
| Biochemical Oxygen Demand (5–Day) | BOD₅ | 1.0 | mg/L | 2 | 2 | 100 |
| Cyanide – Avl. Unfil. React. | CCNAUR | 0.001 | mg/L | 55 | 13 | 24 |
| Chloride | CLIDUR | 0.01 | mg/L | 1 | 1 | 100 |
| Chemical Oxygen Demand | COD | 2.0 | mg/L | 54 | 54 | 100 |
| Dissolved Organic Carbon | DOC | 0.5 | mg/L | 2 | 1 | 50 |
| Hardness | HARDT | 1.0 | mg/L | 5 | 5 | 100 |
| Phenolics (4AAP) | PHNOL | 0.20 | µg/L | 54 | 54 | 100 |
| Total Dissolved Solids | RSF | 1.0 | mg/L | 1 | 1 | 100 |
| Total Suspended Solids | RSP | 0.3 | mg/L | 54 | 54 | 100 |
| Total Solids | RST | 1.0 | mg/L | 54 | 54 | 100 |
| Solvent Extractable (Organic) | SOLEXT | 1.0 | mg/L | 49 | 44 | 90 |
| Sulphide | SSIDUR | 0.001 | µg/L | 3 | 1 | 33 |
| Ammonium | NNHTFR | 0.05 | mg/L | 61 | 15 | 23 |
| Nitrates | NNOTFR | 0.05 | mg/L | 61 | 48 | 74 |
| Nitrite | NNO2FR | 0.005 | mg/L | 54 | 43 | 66 |
| Total Kjeldahl Nitrogen | NNTKUR | 0.05 | mg/L | 61 | 61 | 100 |
| Total Phosphorus | PPUT | 0.02 | mg/L | 61 | 60 | 99 |
| **Heavy Metals** | | | | | | |
| Silver | AGUT | 0.0005 | mg/L | 65 | 42 | 65 |
| Aluminum | ALUT | 0.01 | mg/L | 65 | 65 | 100 |
| Arsenic | ASUT | 0.001 | mg/L | 65 | 9 | 14 |
| Barium | BAUT | 0.005 | mg/L | 65 | 65 | 100 |
| Cadmium | CDUT | 0.0002 | mg/L | 65 | 33 | 51 |
| Chromium | CRUT | 0.001 | mg/L | 65 | 56 | 86 |
| Copper | CUUT | 0.0002 | mg/L | 65 | 63 | 97 |
| Iron | FEUT | 0.01 | mg/L | 65 | 64 | 99 |
| Mercury | HGUT | 0.01 | µg/L | 65 | 58 | 89 |
| Manganese | MNUT | 0.001 | mg/L | 65 | 65 | 100 |
| Nickel | NIUT | 0.001 | mg/L | 65 | 60 | 92 |
| Lead | PBUT | 0.005 | mg/L | 65 | 64 | 99 |
| Selenium | SEUT | 0.001 | mg/L | 65 | 8 | 12 |
| Zinc | ZNUT | 0.001 | mg/L | 65 | 65 | 100 |
| **Bacteriology** | | | | | | |
| E. Coli | ECMF | 4.0 | CH | 39 | 38 | 97 |
| Fecal Coliform MF | FCMF | 4.0 | CH | 38 | 37 | 97 |
| Fecal Streptococcus MF | FSMF | 4.0 | CH | 39 | 38 | 97 |
| Pseudomonas Aeruginosa MF | PSAMF | 2.0 | CH | 39 | 35 | 89 |

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **Organochloride Pesticides/ Chlorobenzenes/PCBs** | | | | | | |
| PCB | P1PCBR | 10.0 | ng/L | 51 | 5 | 10 |
| HCB | X2HCB | 0.1 | ng/L | 51 | 25 | 49 |
| Heptachlor | P1HEPT | 0.1 | ng/L | 51 | 7 | 14 |
| Aldrin | P1ALDR | 0.1 | ng/L | 51 | 13 | 26 |
| p,p–DDE | P1PPDE | 0.1 | ng/L | 51 | 22 | 43 |
| Mirex | P1MIRX | 0.5 | ng/L | 51 | 1 | 2 |
| Alpha BHC | P1BHCA | 0.1 | ng/L | 51 | 51 | 100 |
| Gamma BHC | P1BHCG | 0.1 | ng/L | 51 | 49 | 96 |
| Beta BHC | P1BHCB | 0.1 | ng/L | 51 | 1 | 2 |
| Alpha Chlordane | P1CHLA | 0.2 | ng/L | 51 | 22 | 43 |
| Gamma Chlordane | P1CHLG | 0.2 | ng/L | 51 | 20 | 39 |
| o,p–DDT | P1OPDT | 0.5 | ng/L | 51 | 12 | 24 |
| p,p–DDT | P1PPDT | 0.5 | ng/L | 51 | 18 | 35 |
| p,p–DDD | P1PPDD | 0.5 | ng/L | 51 | 9 | 18 |
| Heptachlor Epoxide | P1HEPE | 0.1 | ng/L | 51 | 3 | 6 |
| Thiodan I | THIO–I | 0.2 | ng/L | 51 | 9 | 18 |
| Thiodan II | THIO–II | 0.4 | ng/L | 51 | 9 | 18 |
| Thiodan Sulphate | THIO–SO4 | 0.4 | ng/L | 51 | 9 | 18 |
| Dieldrin | P1DIEL | 0.2 | ng/L | 51 | 32 | 63 |
| Endrin | P1ENDR | 0.4 | ng/L | 51 | 5 | 10 |
| Oxychlordane | P1OCHL | 0.2 | ng/L | 51 | 2 | 4 |
| Methoxychlor | P1DMDT | 0.4 | ng/L | 51 | 9 | 18 |
| Hexachloroethane | P1HCE | 0.1 | ng/L | 51 | 29 | 57 |
| 1,3,5–Trichlorobenzene | X2125 | 0.2 | ng/L | 51 | 26 | 51 |
| 1,2,4–Trichlorobenzene | X2124 | 0.2 | ng/L | 51 | 29 | 57 |
| 1,2,3–Trichlorobenzene | X2123 | 0.1 | ng/L | 51 | 24 | 47 |
| Hexachlorobutadiene | X1HCBD | 0.1 | ng/L | 51 | 32 | 63 |
| 2,4,5–Trichlorotoluene | X2T245 | 0.1 | ng/L | 51 | 21 | 41 |
| 2,3,6–Trichlorotoluene | X2T236 | 0.1 | ng/L | 51 | 9 | 18 |
| 1,2,4,5–Tetrachlorobenzene | X21245 | 0.1 | ng/L | 51 | 13 | 26 |
| 1,2,3,5–Tetrachlorobenzene | X21235 | 0.1 | ng/L | 51 | 37 | 73 |
| 26A–Trichlorotoluene | X2T26A | 0.1 | ng/L | 51 | 29 | 57 |
| 1,2,3,4–Tetrachlorobenzene | X21234 | 0.1 | ng/L | 51 | 14 | 28 |
| Pentachlorobenzene | X2PNCB | 0.1 | ng/L | 51 | 32 | 63 |
| **Polynuclear Aromatic Hydrocarbons** | | | | | | |
| Naphthalene | PNNAPH | 0.5 | ng/L | 52 | 52 | 100 |
| Acenaphthylene | PNACYN | 0.5 | ng/L | 52 | 39 | 75 |
| Acenaphthene | PNACNE | 0.5 | ng/L | 52 | 49 | 94 |
| Fluorene | PNFLUO | 0.5 | ng/L | 52 | 49 | 94 |
| Phenanthrene | PNPHEN | 0.5 | ng/L | 52 | 51 | 98 |
| Anthracene | PNANTH | 0.5 | ng/L | 52 | 46 | 88 |
| Fluoranthene | PNFLAN | 0.5 | ng/L | 52 | 52 | 100 |
| Pyrene | PNPYR | 0.5 | ng/L | 52 | 52 | 100 |

SUMMARY OF PARAMETER CODES, FREQUENCY OF DETECTION AND DETECTION LIMIT
VALUES FOR THE WHOLE DATA SET

| Descriptive Name | MOE Code | Detection Limit | Units | N | ND | Percent Detected |
|---|---|---|---|---|---|---|
| **Polynuclear Aromatic Hydrocarbons** (Cont'd) | | | | | | |
| Benzo (A) Anthracene | PNBAA | 0.5 | ng/L | 52 | 49 | 94 |
| Chrysene | PNCHRY | 0.5 | ng/L | 52 | 50 | 96 |
| Benzo (B) Fluoranthene | PNBBFA | 0.5 | ng/L | 52 | 45 | 87 |
| Benzo (B–K) Fluoranthene | PNBKF | 0.5 | ng/L | 52 | 44 | 85 |
| Benzo (A) Pyrene | PNABAP | 0.5 | ng/L | 52 | 43 | 83 |
| Indeno (1–2–3–C–D) Pyrene | PNINP | 0.5 | ng/L | 52 | 41 | 79 |
| Dibenzo (A–H) Anthracene | PNDAHA | 0.5 | ng/L | 52 | 31 | 60 |
| Benzo (G–H–I) Perylene | PNGHIP | 0.5 | ng/L | 52 | 42 | 81 |

CH   =   Counts/100 mL.
N   =   Number of samples.
ND   =   Number of detected samples.

## 4.2　　　Water Quality Data Used In Loading Estimates

The analyses which were carried out on the water quality samples depended upon the volume of sample collected. A 20 litre sample was required for the analysis of 88 constituents. A volume of 16 litres was required for the analysis of trace organics (i.e., organochlorine pesticides, PCBs and polynuclear aromatic hydrocarbons) alone.

All analytical work was carried out by the MOE laboratory services branch with the exception of the trace organics. This work was completed by an external laboratory.

Table 4.1 presents a complete list of the parameters which were analyzed. The detection limit, total number of samples submitted for analysis, total number detected and the percent detected is also provided.

Outlined below is the distribution, by parameter group, of parameters analyzed:

- General Chemistry – 23%;
- Bacteriological – 5%;
- Heavy Metals – 17%;
- Organochlorine Pesticides, PCBs and Chlorobenzenes – 39%; and
- Polynuclear Aromatic Hydrocarbons (PAHs) – 16%.

Of the 88 parameters tested, 60 parameters were selected for detailed presentation in this report. The remaining 28 parameters generally had concentrations which were below the detection limit. The concentration database for each sampling location and for all parameters tested is provided in Appendix 3.

All water quality data were obtained from the MOE on floppy disks. The analytical data obtained from the flow weighted composite samples were considered to be representative of the concentration over the duration of the event. The representative contaminant concentration will subsequently be referred to as Event Mean Concentrations (EMCs).

A number of statistical analyses were performed on all the contaminant EMC datasets. These analyses included:

–  Identifying the contaminant detection frequency (see Section 4.3). This information is important for two reasons: it identifies the occurrence and source of a contaminant which may then be compared to other sources for further analyses and future control and; it provides insight as to the type of statistical analyses which should be used.

–  Determining the concentration probability distribution function. This operation is required for subsequent statistical analyses.

–  Establishing the relationship between the EMC and event volume. If a functional relationship between the EMC and event volume exists, the relationship may be used to estimate contaminant loadings. Conversely, if no relationship exists, the Average Event Mean Concentration (AEMC) may be used to estimate contaminant loadings (the AEMC is defined as the mean of the individual EMCs for a given number of events).

–  Comparing the AEMC between land uses. If significant differences exist between land uses, then the AEMC and volume produced by a given land use will have to be used to calculate loadings. If the differences are not significant, then an aggregate database may be used to estimate discharge concentrations for outfalls containing runoff from a combination of land uses.

–  Comparing AEMCs from storm sewer discharges to discharges which contain CSO and to WPCP bypass effluent. This data may be used to gauge the significance and relative importance of the different sources.

## 4.3    Statistical Methodologies for Estimating Event Mean Concentrations (EMCs)

Estimations of the EMC were required for different data sets to assess the possible correlation with flow, land use or sewerage type. If such relationships exist, then only that data which was related to a given flow volume, land use or sewerage type would be used to predict loadings for a given catchment or outfall.

For each constituent data set, there were three basic types of results which were received from the analysis of the water quality samples:

- non-detected;
- rarely detected; and
- frequently detected.

Concentration data is not provided in this report for the non-detected and rarely detected parameters. The Probability Distribution Estimation or PDE method was used for calculating the mean and variance for parameters within a given data set which have a significant number of non-detectable values. Statistical summaries presented in this report have included a measure of variability in the mean estimate described by the Confidence Interval (CI) or the 95 percent confidence limit for the mean, i.e., the mean would lie within the CI limits, ninety five times out of one hundred. The CI for the mean is much narrower than the range of values within the probability distribution.

The Probability Distribution Estimation method is a statistical procedure for the description of left-censored chemical data distributions. Left-censored data distributions are those that have several values at or below the analytical detection limit (the left side of the distribution) with the remainder being above the detection limit. One algorithm of the PDE technique called the Maximum Likelihood Estimation (MLE) technique has been used by the USGS (United States Geological Survey) for the description of chemical data with many less-than-detectable observations and has recently been accepted by the MOE for handling water chemical data in descriptive applications. It is a direct method of estimating the mean and variance (or standard deviation) from the knowledge of the form of the distribution (generally normal or log-normal) and the proportion of observations which are left-censored (less than detection). The estimates of mean and variance are made by using the non-censored data to estimate the characteristics of the distribution, by implicitly extrapolating to provide real estimates for the detection limit data and then estimating the median of the full distribution. It is recommended for use when up to 80% of the distribution is censored and where there is a minimum number (3 to 5) non-censored or deleted values.

For some data sets where criteria for the PDE technique were not met, other more traditional approaches were considered, including:

- replacing all censored data with one-half the detection limit value; and

- linear regression principles to fit a straight line to the non-censored data set on a probability plot (BEAK, 1991).

The method used for each parameter is denoted in the data tables.

Loading estimates were then made after the following evaluations and calculations were made:

- the probability distribution function was determined for the concentration data examined;

- the AEMC for each site and for each land use was calculated;

- comparison of the AEMCs by land use, discharge type (i.e., CSO, storm and the Main WPCP bypass effluent) was carried out; and

- the relationship between the measured EMC and event flow volume was examined for representative data sets.

## 4.4 Contaminant Concentration Characteristics

### 4.4.1 Frequency of Contaminant Detection

The following provides an overview with respect to the frequency of detection for various constituents:

- generally, all constituents which were analyzed, were detected;

- conventional water quality constituents (e.g., TSS, TP, COD, phenols and fecal coliforms) were detected 90 to 100 percent of the time;

- four metals (aluminum, barium, manganese and zinc) were detected 100 percent of the time;

- with the exception of arsenic, cadmium and selenium, the remaining metals were detected more than 80 percent of the time;

- organochlorine pesticides were detected between 2 and 100 percent of the time;

- alpha and gamma BHC were detected in 100 and 96 percent of the samples, respectively;

- chlorobenzenes were detected at frequencies ranging between 18 and 73 percent with 1,2,3,5-tetrachlorobenzene being detected the most frequently; and

- PAHs were detected in 60 to 100 percent of the samples.

4.4.2      Probability Distribution of Water Quality Concentrations

In order to apply the PDE technique for estimating loadings, the nature of the probability distribution needs to be characterized. Some data sets are well represented by a normal distribution while others are approximated by a log-normal distribution.

An analysis of the individual data sets and of the aggregated data sets was made graphically by plotting the cumulative frequency distribution assuming either a normal or log-normal distribution. In most cases, the distribution approximates a straight line on the log-normal probability plot due to the wide variation (generally several orders of magnitude) in the concentrations for a given constituent. Representative log-normal probability distribution plots are presented in Figures 4.1 and 4.2 for data from all outfalls. The aggregation of the data sets shown in Figures 4.1 and 4.2 does not change the nature of the plots since the data from each outfall has similar concentration ranges and median values (see below).

A second method for determining the probability distribution of a data set is to examine values of the third and fourth moment of the distribution – skewness and kurtosis, respectively. Data fitting a normal distribution will have a value of 0 for skewness and 3 for kurtosis. The values of the different moments of the distribution (first: average; second: variance; third: skewness; fourth: kurtosis) are given in Appendix 2 for a variety of parameters (metals, conventional parameters, etc.) using the raw set and log transformed data. The results show that generally the data fits a log-normal distribution which is in agreement with previous studies (NURP, 1983).

It is concluded that the log-normal distribution is a better description of the concentration database than the normal distribution for purposes of making loading estimates.
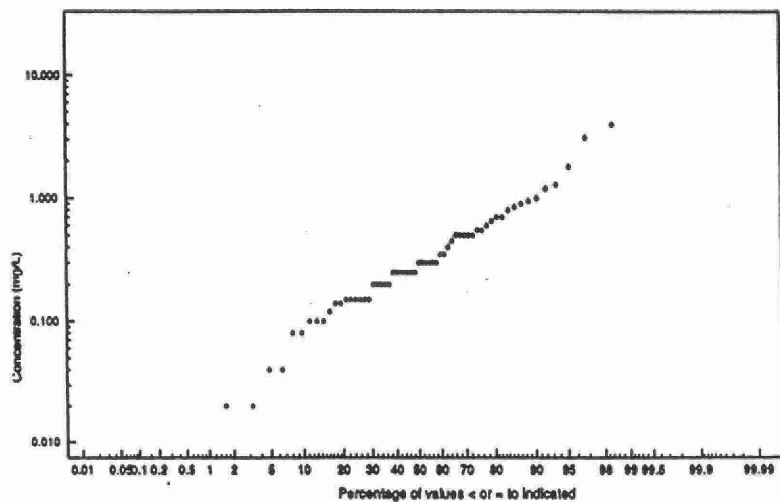
TYPICAL PROBABILITY DISTRIBUTIONS

FIGURE 4-1
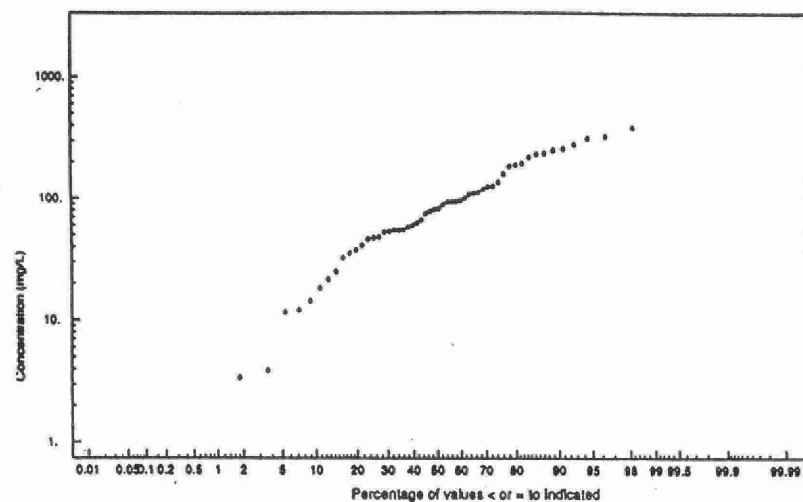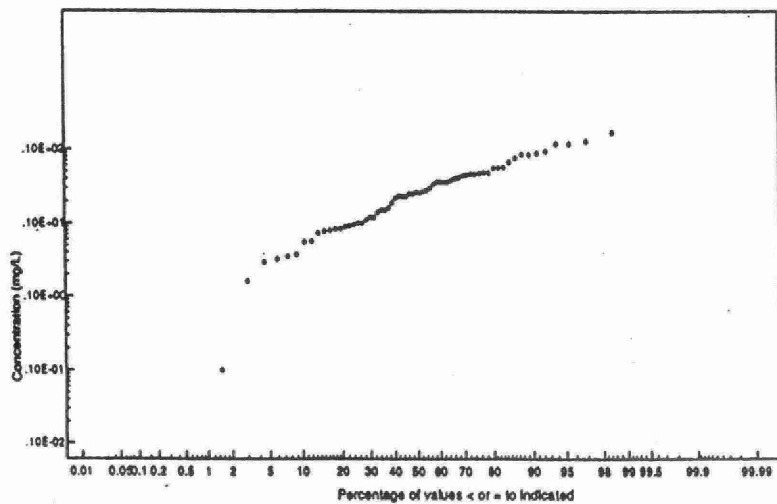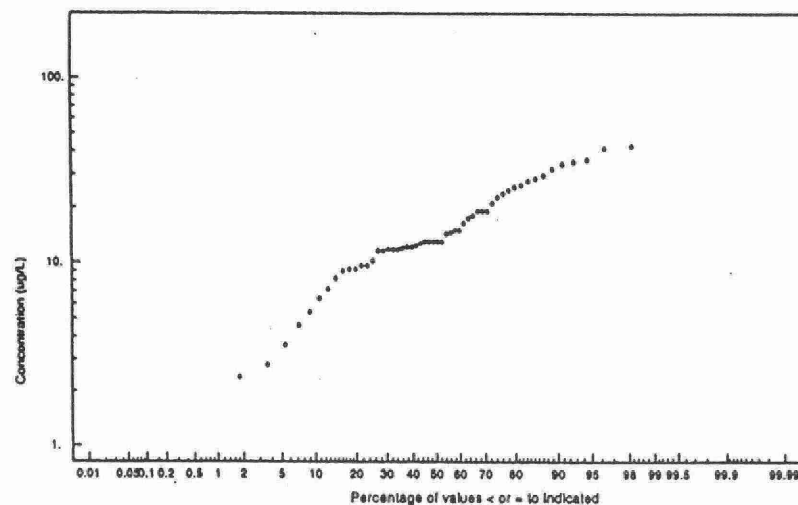
Concentration distribution for Zinc, DL=0.001 mg/L
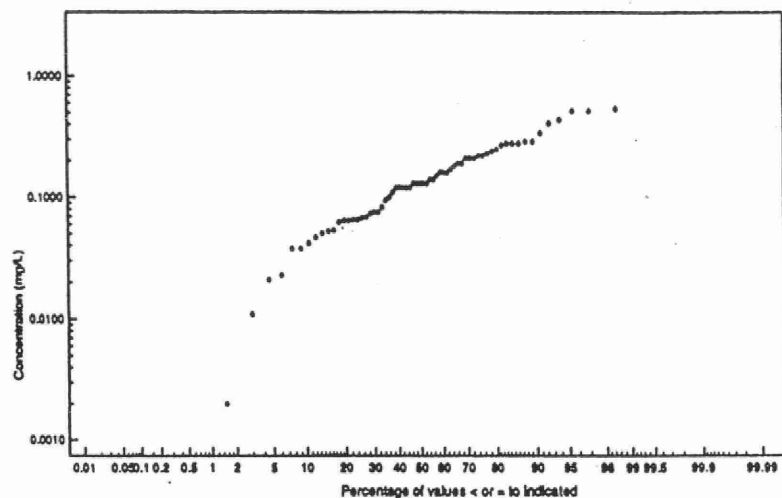
Concentration distribution for Lead, DL=0.005 mg/L
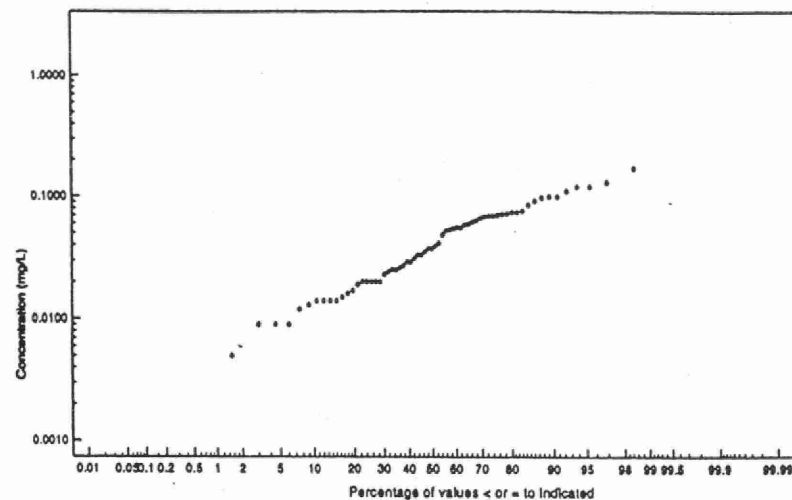
Concentration distribution for 1,2,4 Trichlorobenzene, DL=0.200 ng/L
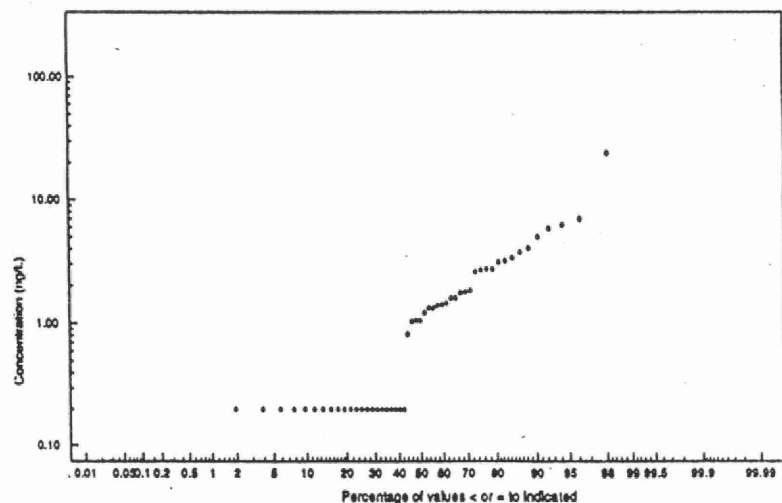
Concentration distribution for Alpha-BHC, DL=0.100 ng/L

TYPICAL PROBABILITY DISTRIBUTIONS

FIGURE 4-2
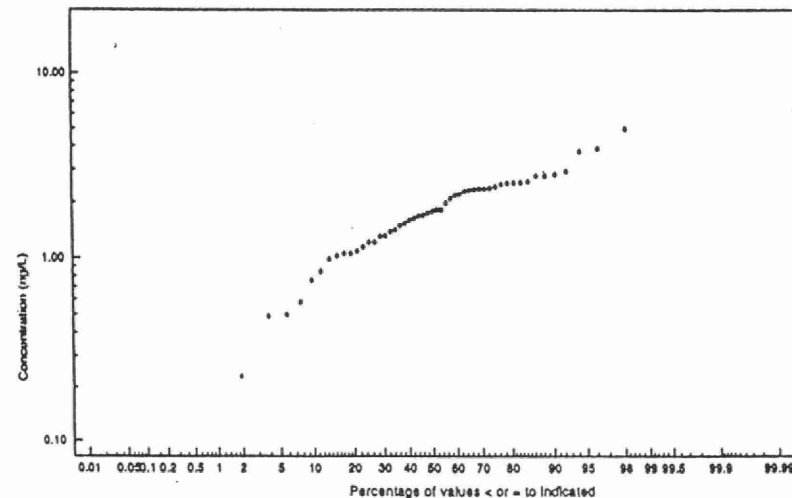
**4.5     Relationship Between Event Mean Concentration and Runoff Volume**

A study carried out by the United States Environmental Protection Agency (NURP, 1983) found that there is no significant relationship between the EMC for a given event and the runoff volume. This potential relationship was examined in this study by plotting EMCs against runoff volumes at various sites and for several constituents.

Typical plots are presented in Figures 4.3 and 4.4 for total suspended solids and iron, respectively. Individual plots for 3 monitoring stations, i.e., Station 4 (Outfall L102), Station 11 (Brooklawn) and Station 7 (Cecil CSO) are given. These stations were selected as they represent various land uses and discharge types. Generally, the plots show that the EMCs are independent of flow volume and remain relatively constant.

To confirm this relationship, the EMC was regressed against event volumes for data collected at a residential and CSO monitoring station (No. 7 and No. 11, respectively) for 50 water quality parameters. The slope of any relationship, the correlation coefficient and the significance of the slope, using the t–test statistic are given in Appendix 2 (Tables A.5 and A.6). The 95 percent confidence interval was used to test the significance of the regressions. A value of less than "T" or equal to 2.0 suggests that the slope is significantly different from zero and that the regression is significant. The results show that there is no significant relationship between the EMC and event volume implying that the EMCs are independent of discharge volume.

The average EMC (AEMC) computed for data collected over all events incorporates the variability within the data set. Pollutant loadings for a given contaminant may therefore be expressed as the product of the AEMC and the volume of runoff for the specified events.

**4.6     Comparison of Concentrations from Various Land Uses**

Intuitively, urban runoff contaminant concentrations have been thought to be dependent upon land use characteristics. This conclusion is logical due to the variation in activities and contaminant sources for the different land uses. Recent studies (NURP, 1983; Marsalek, 1987) have, however, found no significant difference in AEMCs for different land uses. The following steps were carried out in order to determine whether the AEMCs for this study area vary based on different land use types.

FIGURE 4·3

Concentration-Flow Relation Station #4, Total Suspended Solids
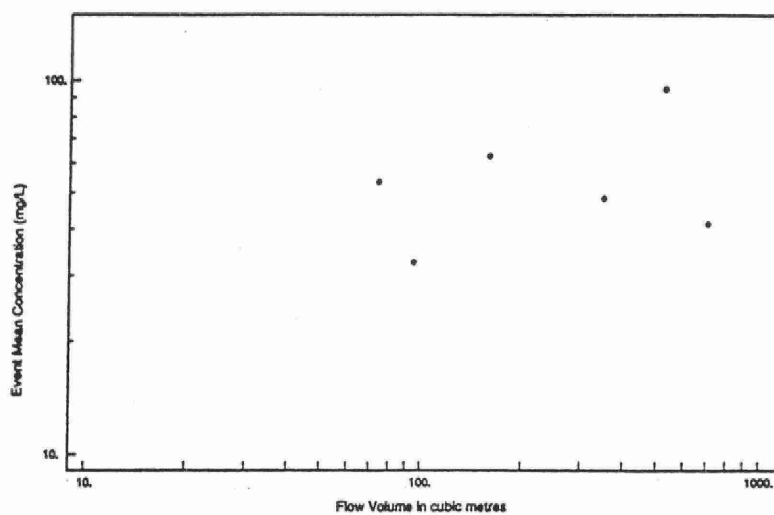


Concentration-Flow Relation Station #7, Total Suspended Solids
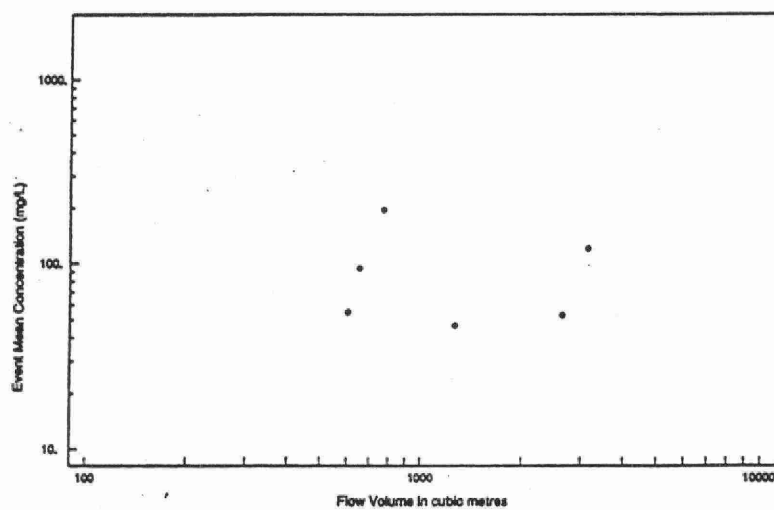


Concentration-Flow Relation Station #11, Total Suspended Solids
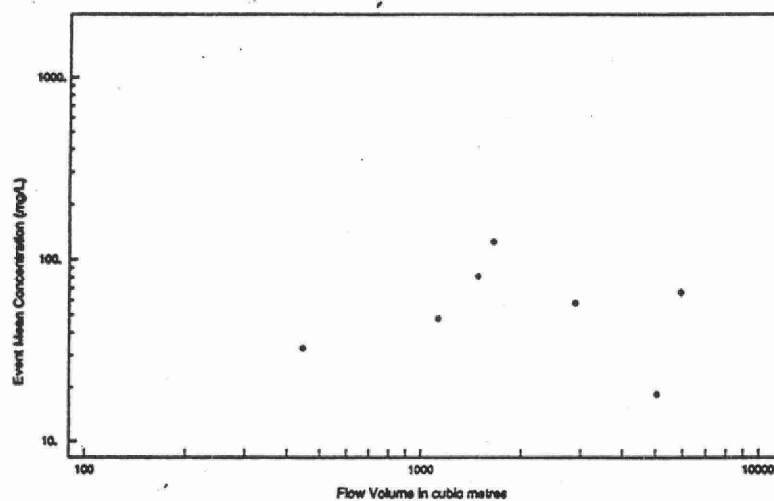


TYPICAL SUSPENDED SOLIDS
CONCENTRATION - FLOW RELATION

FIGURE 4·4

Concentration-Flow Relation Station #4, Iron
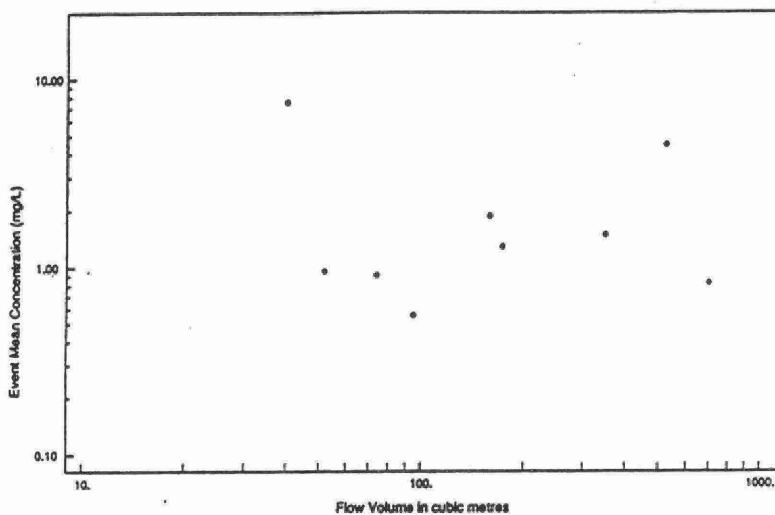


Concentration-Flow Relation Station #7, Iron
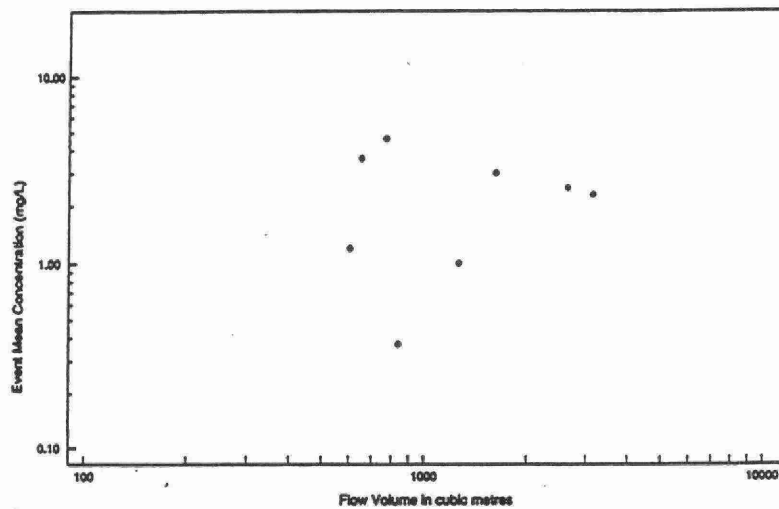


Concentration-Flow Relation Station #11, Iron
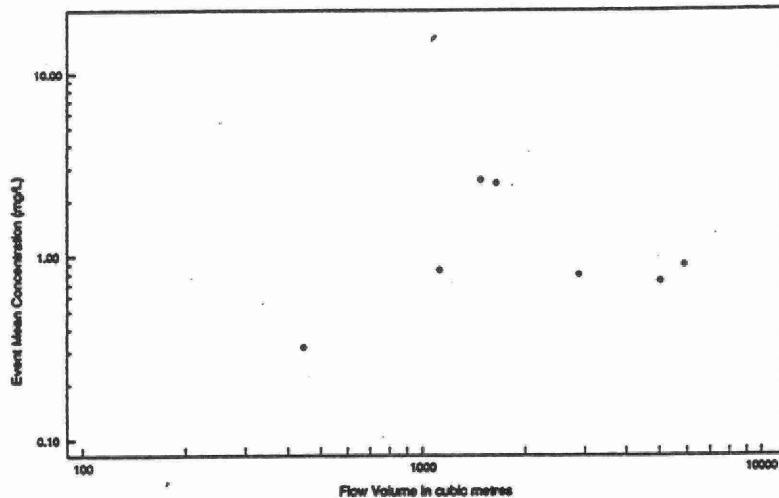


# TYPICAL IRON
# CONCENTRATION- FLOW  RELATION

Data were obtained for the following land uses which were considered in this study:

- residential;
- commercial; and
- industrial.

Data were also obtained for storm sewers which contain CSO.

In Table 4.2, a summary of the estimated AEMCs for the more frequently detected water quality parameters are presented by land use. The AEMC values and their corresponding confidence intervals were computed by grouping the data from the monitoring stations representative of similar dominant land uses and using the MLE and other techniques outlined earlier in this report. Detailed tables of AEMCs, number of samples, number of detections and confidence intervals are provided in Appendix 3.

Data from the various land uses were compared statistically to data from the residential sites. The comparisons were considered appropriate given that residential activities dominated the land uses at a minimum of 70 percent of the available land. Data comparisons between commercial–residential, industrial–residential and CSO–residential sites were examined statistically for each parameter using the t–statistic. The results are tabulated in Appendix 2, Table A.7 and A.8.

In a technical sense, the differences are said to be statistically significant at a 5% level of significance if the t–statistic is larger than the appropriate test value. As a rough rule of thumb, the mean concentrations are significantly different if the t–statistic is larger than approximately 2. Analyses of the data indicates that, for each comparison, only 5 to 10 out of 25 parameters are significantly different (i.e., commercial–residential, industrial–residential and CSO–residential). That is, most of the parameters have the same mean value, irrespective of its origins when the variation in the data is accounted for. Furthermore, several parameters show significant differences for only one land use comparison. For example, mercury shows significant differences only between CSO and residential sites and beryllium shows significant differences only between industrial and residential land uses.

Qualitatively, the finding that the different land uses have essentially the same mean values, is supported by the fact that none of the land uses of commercial or industrial are truly single land uses. Rather, the monitoring stations represent catchments which have a significant component of the designated land use in addition to some residential activity. For the catchments designated as CSOs,

## Table 4.2 ESTIMATED EVENT MEAN CONCENTRATION FOR WATER QUALITY PARAMETERS BY LAND USE

| PARAMETER | Units | COMMERCIAL STATION (#6) | RESIDENTIAL STATIONS (#4, #10, #11) | INDUSTRIAL STATIONS (#3, #5, #9) | CSO STATIONS (#7 & #8) |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Alkalinity (as CaCO3) | mg/L | 103.000 | 63.300 | 110.000 | 112.000 |
| Cyanide - Avl. Unfil. React. | mg/L | 0.002# | 0.007# | 0.002# | 0.007# |
| Chemical Oxygen Demand | mg/L | 601.000 | 724.000 | 837.000 | 857.000 |
| Phenolics (4AAP) | ug/L | 17.200 | 17.400 | 14.300 | 19.200 |
| Total suspended solids | mg/L | 220.000 | 88.600 | 172.000 | 115.000 |
| Total solids | mg/L | 722.000 | 307.000 | 468.000 | 538.000 |
| Solvent extractable (organic) | mg/L | 7.080 | 7.910 | 9.680 | 9.950 |
| Ammonium | mg/L | 0.088 | 0.480# | 0.190 | 0.048 |
| Nitrates | mg/L | 0.990 | 3.660 | 10.100 | 0.530 |
| Nitrite | mg/L | 0.110 | 0.037 | 0.047 | 0.055 |
| Total Kjeldahl Nitrogen | mg/L | 1.790 | 2.370 | 2.930 | 2.540 |
| Total Phosphorus | mg/L | 0.500 | 0.420 | 0.650 | 0.550 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | CH | 18,200* | 155,000.000 | 38,800* | 445,000.000 |
| Fecal Coliform MF | CH | 21,900* | 289,000.000 | 38,300* | 543,000.000 |
| **HEAVY METALS** | | | | | |
| Silver | mg/L | 0.005 | 0.003 | 0.002 | 0.003 |
| Aluminum | mg/L | 6.650 | 1.380 | 1.570 | 1.490 |
| Arsenic | mg/L | 0.001# | 0.001# | 0.002# | 0.001# |
| Barium | mg/L | 0.074 | 0.026 | 0.051 | 0.057 |
| Cadmium | mg/L | 0.001 | 0.001 | 0.018 | 0.001 |
| Chromium | mg/L | 0.011 | 0.009 | 0.027 | 0.011 |
| Copper | mg/L | 0.066* | 0.027 | 0.460* | 0.064 |
| Iron | mg/L | 12.600 | 2.950 | 5.470 | 4.870 |
| Mercury | ug/L | 0.088 | 0.051 | 0.039 | 0.081 |
| Manganese | mg/L | 0.250 | 0.120 | 0.130 | 0.300 |
| Nickel | mg/L | 0.028 | 0.007 | 0.015 | 0.010 |
| Lead | mg/L | 0.084 | 0.037 | 0.048 | 0.063 |
| Selenium | mg/L | 0.001# | 0.001# | 0.001# | 0.001# |
| Zinc | mg/L | 0.300 | 0.120 | 0.320 | 0.170 |

NOTE: All estimates by MLE method except: *regression used, #traditional method used
CH = counts/100 mL

## Table 4.2(cont.)    ESTIMATED EVENT MEAN CONCENTRATION FOR WATER QUALITY PARAMETERS BY LAND USE

| PARAMETER | Units | COMMERCIAL STATION (#6) | RESIDENTIAL STATIONS (#4, #10, #11) | INDUSTRIAL STATIONS (#3, #5, #9) | CSO STATIONS (#7 & #8) |
|---|---|---|---|---|---|
| **ORGANOCHLORIDE PESTICIDES/ CHLOROBENZENES** | | | | | |
| Alpha-BHC | ng/L | 3.300 | 2.170 | 1.270 | 2.110 |
| Gamma-BHC | ng/L | 2.850 | 1.370 | 0.520 | 2.360 |
| 1,2,4-Trichlorobenzene | ng/L | ND | 3.250* | 3.200 | 2.840 |
| 1,2,3-Trichlorobenzene | ng/L | 0.910# | 2.590 | 6.320* | 1.820 |
| Hexachlorobenzene | ng/L | ND | 0.500 | 0.170 | 0.360 |
| PP DDE | ng/L | ND | 0.160 | 0.170 | 0.280 |
| Alpha Chlordane | ng/L | 3.300 | 0.500 | 0.390 | 0.490 |
| Gamma Chlordane | ng/L | 2.850 | 0.420 | ND | 0.600 |
| OP DDT | ng/L | 0.170 | 0.260 | 0.380 | 0.300 |
| PP DDT | ng/L | ND | 1.160 | 0.830 | 1.110 |
| Dieldrin | ng/L | ND | 1.650 | 0.220 | 0.570 |
| Hexachloroethane | ng/L | ND | 0.240 | 0.140 | 0.160 |
| Trichlorobenzene 1-3-5 | ng/L | ND | 0.420 | 0.690 | 2.540 |
| Hexachlorobutadiene | ng/L | ND | 0.400 | 0.220 | 0.350 |
| Trichlorotoluene 2-4-5 | ng/L | 0.910 | 0.660 | 1.110 | 2.570 |
| Tetrachlorobenzene 1-2-3-5 | ng/L | 0.540 | 3.290 | 2.390 | 2.740 |
| Trichlorotoluene 2-6-A | ng/L | 3.910 | 0.940 | 0.440 | 1.220 |
| Pentachlorobenzene | ng/L | 0.350 | 0.730 | 0.450 | 0.680 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | ng/L | 198.0 | 216.0 | 366.0 | 162.0 |
| Acenaphthylene | ng/L | 47.1 | 17.0 | 16.0 | 18.0 |
| Acenaphthene | ng/L | 48.5 | 135.0 | 81.0 | 46.0 |
| Fluorene | ng/L | 91.2 | 131.0 | 132.0 | 91.0 |
| Phenanthrene | ng/L | 523.0 | 646.0 | 812.0 | 847.0 |
| Anthracene | ng/L | 37.6 | 71.0 | 34.0 | 41.0 |
| Fluoranthene | ng/L | 690.0 | 1,019.0 | 870.0 | 1,136.0 |
| Pyrene | ng/L | 619.0 | 777.0 | 700.0 | 875.0 |
| Benzo (A) Anthracene | ng/L | 436.0 | 289.0 | 263.0 | 261.0 |
| Chrysene | ng/L | 332.0 | 456.0 | 332.0 | 482.0 |
| Benzo (B) Fluoranthene | ng/L | 261.0 | 618.0 | 722.0 | 557.0 |
| Benzo (B-K) Fluoranthene | ng/L | 216.0 | 782.0 | 364.0 | 334.0 |
| Benzo (A) Pyrene | ng/L | 195.0 | 337.0 | 372.0 | 277.0 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 162.0 | 345.0 | 186.0 | 322.0 |
| Dibenzo (A-H) Anthracene | ng/L | 9.3 | 137.0 | 13.0 | 172.0 |
| Benzo (G-H-I) Perylene | ng/L | 261.0 | 391.0 | 270.0 | 331.0 |

NOTE: All estimates by MLE method except: *regression used, #traditional method used

CH = counts/100 mL

ND = No Data

comparison of the results is further complicated due to the fact that the overflows contain significant volumes of stormwater from partially separated areas.

The geochemical rationale as to why the concentrations are similar awaits further investigation. For parameters which are mainly dominated by atmospheric deposition, the rationale is self-evident. For other parameters, a relevant hypothesis to explain these findings include the fact that erosion and deposition of dust across a metropolitan urban area is sufficient to average out local effects and cause similar mean values in a concentration data distribution set which varies by more than an order of magnitude. This suggests that significant differences may be demonstrated only in a well defined homogeneous land use having a small catchment area.

Accordingly, it is concluded that concentrations in runoff from different land use along the Toronto Waterfront are essentially the same in a global context for most parameters due mainly to the mixture of land uses and the large extent of residential areas in all catchments. Hence, aggregation of the data is an appropriate approach for estimating loadings to the waterfront. The aggregated database for catchments with CSO, without CSO and the Main WPCP bypass is presented in Table 4.3. This database was used to prepare the loading estimates. A comparison of the concentrations for the sites which did not contain CSO in this study to those from other studies is shown in Table 4.4. The comparison indicates that the concentrations observed in this study lie within the range or within one order of magnitude of those observed in other studies in Ontario and the United States.

The concentrations of different parameters from the residential sets and CSO sites are similar, although slightly higher AEMCs are observed for the CSO data (see Table 4.3). The differences were not as significant as typically expected for combined sewer outflows. Typically, CSO discharges contain higher concentrations of bacteria and nutrients (see Table 4.5). The similarity in concentrations between the stormwater and CSO catchments within this study is largely the result of the high degree of sewer separation which now exists in most of the catchments which drain to the CSO discharge points. This results in relatively lower frequencies and volumes of CSO. Data provided in the Scarborough Pollution Control Plan Study (Proctor and Redfern, 1988) estimates the CSOs on average make up 10 percent of the sewer discharges for an average event. A comparison of concentrations for sites which contained CSO in this study to those from three other studies, namely, the U.S. EPA NURP study, the MOE Humber TAWMS study and the UGLCC study, is shown in Table 4.5. This comparison indicates that the CSO concentrations observed in this study are generally lower.

**Table 4.3    ESTIMATED EVENT MEAN CONCENTRATION FOR WATER QUALITY PARAMETERS FOR CATCHMENTS WITH AND WITHOUT CSOs AND FOR THE MAIN WPCP BYPASS**

| PARAMETER | Units | EMC FOR STATIONS WITH NO CSO | EMC FOR STATIONS WITH CSO | MAIN WPCP BYPASS |
|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | |
| Alkalinity (as CaCO3) | mg/L | 83.600 | 112.000 | 283.000* |
| Cyanide - Avl. Unfil. React. | mg/L | 0.005# | 0.007* | 0.080* |
| Chemical Oxygen Demand | mg/L | 740.000 | 857.000 | 247.000* |
| Phenolics (4AAP) | ug/L | 16.300 | 19.200 | 158.000* |
| Total suspended solids | mg/L | 128.000 | 115.000 | 359.000* |
| Total solids | mg/L | 421.000 | 538.000 | 763.000* |
| Solvent extractable (organic) | mg/L | 7.950 | 9.950 | 41.500* |
| Ammonium | mg/L | 0.270 | 0.048# | 29.000* |
| Nitrates | mg/L | 4.890 | 0.530 | 0.037* |
| Nitrite | mg/L | 0.052 | 0.055 | 0.010* |
| Total Kjeldahl Nitrogen | mg/L | 2.420 | 2.540 | 57.700* |
| Total Phosphorus | mg/L | 0.490 | 0.550 | 16.100* |
| **BACTERIOLOGY** | | | | |
| E-Coli | CH | 177,000.000* | 445,000.000 | 4,650,000.000* |
| Fecal Coliform MF | CH | 403,000.000 | 543,000.000 | 5,900,000.000* |
| **HEAVY METALS** | | | | |
| Silver | mg/L | 0.003 | 0.003 | 0.083* |
| Aluminum | mg/L | 1.760 | 1.490 | 3.050* |
| Arsenic | mg/L | 0.001# | 0.001# | ND |
| Barium | mg/L | 0.043 | 0.057 | 0.260* |
| Cadmium | mg/L | 0.005 | 0.001 | 0.012* |
| Chromium | mg/L | 0.015 | 0.011 | 0.330* |
| Copper | mg/L | 0.160 | 0.064 | 0.500* |
| Iron | mg/L | 4.420 | 4.870 | 32.500* |
| Mercury | ug/L | 0.050 | 0.081 | 0.510* |
| Manganese | mg/L | 0.140 | 0.300 | 0.200* |
| Nickel | mg/L | 0.012 | 0.010 | 0.056* |
| Lead | mg/L | 0.046 | 0.063 | 0.130* |
| Selenium | mg/L | 0.001# | 0.001# | ND |
| Zinc | mg/L | 0.190 | 0.170 | 0.770* |

NOTE: All estimates by MLE method except, * regression used, # traditional method used, **geometric mean
      CH = counts/100 mL
      STATIONS WITH NO CSO = #3, #4, #5, #6, #9, #10, & #11
      STATIONS WITH CSO   = #7 & #8
      ND = Not Detected

**Table 4.3(cont.)**    ESTIMATED EVENT MEAN CONCENTRATION FOR WATER QUALITY
PARAMETERS FOR CATCHMENTS WITH AND WITHOUT CSOs AND FOR THE
MAIN WPCP BYPASS

| PARAMETER | Units | EMC FOR STATIONS WITH NO CSO | EMC FOR STATIONS WITH CSO | MAIN WPCP BYPASS |
|---|---|---|---|---|
| **ORGANOCHLORIDE PESTICIDES/ CHLOROBENZENES** | | | | |
| Alpha-BHC | ng/L | 1.880 | 2.110 | 0.570* |
| Gamma-BHC | ng/L | 1.140 | 2.360 | 2.130 |
| 1,2,4-Trichlorobenzene | ng/L | 6.010 | 2.840 | 5.110* |
| 1,2,3-Trichlorobenzene | ng/L | 2.430* | 1.820* | ND |
| Hexachlorobenzene | ng/L | 0.320 | 0.360 | 0.374** |
| PP DDE | ng/L | 0.160 | 0.280 | 0.293** |
| Alpha Chlordane | ng/L | 0.680 | 0.490 | 0.283# |
| Gamma Chlordane | ng/L | 0.600 | 0.600 | 0.164# |
| OP DDT | ng/L | 0.320 | 0.300 | 0.184# |
| PP DDT | ng/L | 1.090 | 1.110 | 0.416# |
| Dieldrin | ng/L | 0.800 | 0.570 | 0.322** |
| Hexachloroethane | ng/L | 0.180 | 0.160 | 0.085# |
| Trichlorobenzene 1-3-5 | ng/L | 0.480 | 2.540 | 0.156# |
| Hexachlorobutadiene | ng/L | 0.320 | 0.350 | ND |
| Trichlorotoluene 2-4-5 | ng/L | 0.830 | 2.570 | ND |
| Tetrachlorobenzene 1-2-3-5 | ng/L | 3.250 | 2.740 | 0.833** |
| Trichlorotoluene 2-6-A | ng/L | 0.760 | 1.220 | 0.111** |
| Pentachlorobenzene | ng/L | 0.620 | 0.680 | 1.507** |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | |
| Naphthalene | ng/L | 215.0 | 162.0 | 125.9** |
| Acenaphthylene | ng/L | 18.0 | 18.0 | 0.4# |
| Acenaphthene | ng/L | 96.0 | 46.0 | 12.6** |
| Fluorene | ng/L | 108.0 | 91.0 | 22.7** |
| Phenanthrene | ng/L | 555.0 | 847.0 | 78.6** |
| Anthracene | ng/L | 51.0 | 41.0 | 2.7# |
| Fluoranthene | ng/L | 782.0 | 1,136.0 | 80.9** |
| Pyrene | ng/L | 615.0 | 875.0 | 90.7** |
| Benzo (A) Anthracene | ng/L | 249.0 | 261.0 | 4.9# |
| Chrysene | ng/L | 333.0 | 482.0 | 6.5# |
| Benzo (B) Fluoranthene | ng/L | 553.0 | 557.0 | 1.2# |
| Benzo (B-K) Fluoranthene | ng/L | 570.0 | 334.0 | 1.2# |
| Benzo (A) Pyrene | ng/L | 320.0 | 277.0 | 1.0# |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 274.0 | 322.0 | ND |
| Dibenzo (A-H) Anthracene | ng/L | 99.0 | 172.0 | ND |
| Benzo (G-H-I) Perylene | ng/L | 335.0 | 331.0 | ND |

NOTE: All estimates by MLE method except, * regression used, # traditional method used, **geometric mean

CH = counts/100 mL

STATIONS WITH NO CSO = #3, #4, #5, #6, #9, #10, & #11

STATIONS WITH CSO   = #7 & #8

ND = Not Detected

TABLE 4.4:          COMPARISON OF STORMWATER EMC DATA

| Parameter | Units | Wet Weather Outfall Study 1989 | NURP | UGLCC |
|---|---|---|---|---|
| COD | mg/L | 740 | 57–73 | – |
| TSS | mg/L | 128 | 67–101 | – |
| TKN | mg/L | 2.42 | 1.18–1.90 | – |
| TP | mg/L | 0.49 | 0.20–0.38 | 0.16–0.37 |
| Cadmium | mg/L | 0.005 | 0.014 | 0.006 |
| Copper | mg/L | 0.16 | 0.1 | 0.009–0.087 |
| Iron | mg/L | 4.42 | – | 3.0–11.4 |
| Lead | mg/L | 0.046 | 0.006–0.46 | 0.06–0.45 |
| Mercury | $\mu$g/L | 0.05 | 0.6–1.2 | 0.018–0.18 |
| Nickel | mg/L | 0.012 | 0.001–0.18 | 0.003–0.039 |
| Zinc | mg/L | 0.19 | 0.01–2.4 | 0.16–0.48 |
| Alpha BHC | ng/L | 1.88 | 2.7 | – |
| Gamma BHC | ng/L | 1.14 | 7.01 | – |
| Benzo(b)Flouranthene | ng/L | 553 | 1,000–5,000 | – |
| Indeno(1,2,3–c–d)Pyrene | ng/L | 274 | 4,000 | – |
| Fecal Coliforms | Counts/ 100 mL | 403,000 | 21,000 | – |

TABLE 4.5:        COMPARISON OF EMC DATA

| Parameter | Units | Wet Weather Outfall Study 1989 (Stations E11 and Cecil CSO) | U.S. EPA NURP [1] | TAWMS Humber [2] | UGLCC [3] |
|---|---|---|---|---|---|
| COD | mg/L | 857 | 132 | – | – |
| TSS | mg/L | 115 | 184 | 196 | – |
| Nitrate | mg/L | 0.53 | 1.0 | – | – |
| Nitrite | mg/L | 0.055 | 0.1 | – | – |
| TKN | mg/L | 2.54 | 6.5 | – | – |
| TP | mg/L | 0.55 | 2.4 | 1.96 | 0.4–3.4 |
| Chromium | mg/L | .011 | 0.09 | – | – |
| Copper | mg/L | .064 | 0.102 | 0.119 | 0.1–0.14 |
| Lead | mg/L | .063 | 0.346 | 0.182 | 0.05–0.29 |
| Zinc | mg/L | .170 | 0.348 | 0.300 | 0.24–0.34 |
| Fecal Coliforms | Counts/100 mL | 543,000 | 1,000,000 | 1,650,000 | – |

1    E.D. Driscoll, "Combined Sewer Overflow Analysis Methodology". Woodward Clyde Consultants. Oakland, N.J., October 1986.

2    W.M. Wong, "Humber Sewershed Combined Sewer Overflow Study Technical Report No. 7". Toronto Area Watershed Management Strategy Study, June 1986.

3    J. Marsalek and H.Y.F. Ng, "Contaminants in Urban Runoff in the Upper Great Lakes Connecting Channels Area". Environment Canada, June 1987.

The estimated AEMCs for the Main WPCP bypass after primary treatment are presented in Table 4.3. In general, the WPCP bypass has significantly higher AEMCs than the outfalls with and without CSO for general chemistry, bacteriological and heavy metal parameter groups. The higher concentrations are associated with the sanitary sewage component of the plant's combined sewage influent. The influent contains many domestic and industrial discharge sources.

The WPCP bypass has lower concentrations of organochloride pesticides, chlorbenzenes and PAH's compared to both sewer outfall with and without CSO.

The AEMC's for the Main WPCP Bypass are an order of magnitude higher for Phenolics, Ammonia, TKN, TP, all bacteriological parameters tested and for seven of the fifteen heavy metals tested. They are within same order of magnitude for most of the organic parameters except PP DDT, Hexachloroethane, and Trichlorobenzene 1-2-3-5, which are one order of magnitude lower and Pentachlorobenze which is one order of magnitude higher. AEMC's for PAH's are within the same order of magnitude except for Acenaphthylene, Phenanthrene, Fluoranthene and Pyrene which are one order of magnitude lower and Benzo (A) Anthracene, Chrysene, Benzo (B) Fluoranthene, Benzo (B-K), Fluoranthene and Benzo (A) Pyrene which were found to be two orders of magnitude lower.

## 4.7 Comparison of Observed Wet to Dry Weather Discharge Concentrations to and Water Quality Objectives

A summary is provided in Table 4.6 of chemical concentrations observed in wet and dry weather sewer outfall discharges with water quality standards objectives contained in the following criteria documents:

- Metro Toronto Sewer Use By-Laws:
    - Sanitary Sewer Systems, and
    - Storm Sewer Systems;

- Provincial Water Quality Objectives (PWQO) for the protection of swimming areas or aquatic life; and

- Canadian Water Quality Guidelines.

**TABLE 4.6(a):** COMPARISON OF CONCENTRATIONS MEASURED IN WATERFRONT STUDIES WITH VARIOUS WATER QUALITY CRITERIA

| Parameter | | Discharge to Sanitary Sewer By-Law Target Concentration | Discharge to Storm Sewer By-Law Target Concentration | PWQO Aquatic Life (Drinking Water) | Observed Concentration Dry Weather Outfall | Observed Concentration Wet Weather Outfalls | Observed Concentration RL Clark WFP Backwash | Observed Concentration WPCP Effluent | Observed Concentration Weather CSO's |
|---|---|---|---|---|---|---|---|---|---|
| BOD | (mg/L) | 300 | 15 | - | 7-19 | 420 | <1 | 11-27 | - |
| Fecal Coliforms | (CNT/dL) | - | 15 | - | 38,000-301,000 | 10,000-16E6 | <2 | 10-10⁵* | 30,000-10E6 |
| SS | (mg/L) | 350 | 15 | 0 | 17-37 | 87-188 | 63-1100 | 13-19 | 85-156 |
| TP | (mg/L) | 10 | - | .03 | 0.2-0.5 | 0.3-0.7 | 0.5-0.9 | .48-.75 | .39-.77 |
| TKN | (mg/L) | 100 | - | - | 1.8-4 | 1.9-3 | 2.6-6.2 | .22-30 | 2.2-3.0 |
| Phenolics | (mg/L) | 1 | - | .001 | 4-6 | .014-.019 | <0.005 | .009-.011 | .018-.021 |
| NO$_3$ | (mg/L) | - | - | (10) | 3.1-7.9 | 1.1-2.1 | .33-.44 | 0.35-0.39 | .16-1.7 |
| Al | (mg/L) | 50 | - | - | .25-.35 | 1.2-2.5 | 21-29 | .098-.41 | 1.1-1.9 |
| Fe | (mg/L) | 50 | - | 0.3 | .63-1.0 | 2.7-7.2 | 3.5-6.0 | 1.7-2.4 | 3.1-7.6 |
| Cr | (mg/L) | 5 | 0.2 | 0.1 | 0.008-0.13 | .009-.025 | .023-.062 | .008-.011 | .006-.021 |
| Pb | (mg/L) | 5 | 0.05 | 0.025 | 0.008-0.012 | 0.038-0.055 | .013-.033 | .017-.021 | .049-.081 |
| Mn | (mg/L) | 5 | - | - | 0.11-.17 | -.12-.17 | 0.15-0.24 | .15-.26 | .19-.48 |
| Se | (mg/L) | 5 | - | 0.1 | <0.001 | <.001 | <0.001 | <.001 | .001 |
| Ag | (mg/L) | 5 | - | .0001 | <0.01 | .002-.005 | 0.007-0.25 | .007-.015 | - |
| Cu | (mg/L) | 3 | 0.01 | 0.005 | .040-0.071 | .045-.46 | .013-.054 | .011-.023 | .033-.12 |
| Ni | (mg/L) | 3 | 0.05 | 0.025 | .008-.012 | .009-.016 | 0.006-0.016 | .043-.068 | .006-.014 |
| Zn | (mg/L) | 3 | 0.05 | 0.030 | 0.42-.065 | .14-.26 | 0.019-0.18 | .054-.074 | .14-2.1 |
| Total Cyanide | (mg/L) | 2 | - | .005 | - | .005 | <0.005 | .031-.038 | - |
| As | (mg/L) | 1 | - | 0.1 | .002-.004 | <.001 | 0.01-0.061 | <.001 | .001 |
| Cd | (mg/L) | 1 | 0.001 | .0002 | <0.002 | .001-.024 | <0.005 | .002-.004 | .001 |
| Hg | (mg/L) | 0.1 | 0.001 | 0.0002 | <0.00001 | .00004-.00006 | 0.000035-0.000058 | .0004-.0001 | |
| PCBs | (µg/L) | 0 | 0 | .001 | <0.02 | - | <0.001 | NC | - |
| Solvent Extractable | | - | - | - | - | 5-11 | | 2.2-2.6 | - |

* Plant Operating Data - lower end of range is for operating conditions using chlorination, while upper end is for periods of non-chlorination.

Reference: Beak Consultants Limited and Paul Theil Associates Limited, 1991 Study of 1984 Dry Weather Discharges to the Metropolitan Toronto Waterfront, report submitted to the Ontario Ministry of the Environment.

TABLE 4.6(b):     COMPARISON OF CONCENTRATIONS (µg/L) MEASURED IN WATERFRONT STUDIES WITH GUIDELINES FOR ORGANIC PARAMETERS*

| Compound (All Units µg/L) | Guidelines | Observed Concentration Dry Weather Outfalls | Observed Concentration Wet Weather Outfalls | Observed Concentration WFP Backwash | Observed Concentration WPCP Effluent |
|---|---|---|---|---|---|
| Phenols | 2.0a | 8 | 17 | <0.7 | 11 |
| Toluene | 300b | 0.02 | - | <0.1 | <0.3 |
| Benzene | 300b | 0.02 | - | <0.1 | <0.3 |
| Alpha-BHC | 0.092c | 0.001 | 0.001 | 0.003 | <0.001 |
| Gamma-BHC | 0.186c | 0.0005 | 0.001 | 0.006 | 0.01 |
| Total PCB | 0.001d | <0.005 | <.25 | <0.005 | <0.005 |
| Anthracene | - | <0.02 | 0.051 | <0.1 | <0.001 |
| Fluoranthene | 42c | <0.02 | 0.782 | <0.1 | 0.007 |
| Pyrene | - | <0.02 | 0.615 | <0.1 | 0.016 |
| Benzo(A)Anthracene | - | <0.04 | 0.249 | <0.2 | <0.001 |
| Chrysene | - | <0.02 | 0.333 | <0.1 | 0.003 |
| Hexachlorobutadiene | 0.1b | <0.0004 | 0.00024 | <0.00005 | 0.0004 |
| Biz-2-Ethyl Hexyl Phthalate | 6b | 7.4 | - | 4 | <0.002 |
| Dichlorobenzene 1,2 | 2.5b | <.02 | - | <0.08 | <0.0001 |
| Dichlorobenzene 1,3 | - | <0.02 | - | <0.08 | <0.0003 |
| Dichlorobenzene 1,4 | 4.0b | <0.02 | - | <0.2 | <0.0003 |
| Trichlorobenzene 1,2,4 | 0.5b | 0.002 | 0.005 | 0.004 | 0.03 |
| Trichlorobenzene 1,2,3 | 0.9b | <.0001 | 0.002 | 0.007 | 0.008 |
| Trichlorobenzene 1,3,5 | 0.65b | <.00005 | <0.0004 | <0.0005 | 0.002 |
| Tetrachlorobenzene 1,2,3,4 | 0.1b | <.00005 | <0.0004 | <0.0005 | 0.009 |
| Pentachlorobenzene | 0.03b | <0.00005 | 0.0008 | <.0003 | 0.002 |
| Hexachlorobenzene | 0.0065b | <0.00005 | 0.0003 | <0.0003 | 0.004 |
| Heptachlor Epoxides and Heptachlor | 0.01b | <.00001 | <.00005 | <0.00001 | <0.00005 |

* Values which are "less than" are average of data above detection limit plus assignment of values at detection limit as one-half of detection limit. Values which do not have "less than" sign are calculated by probability distribution estimation technique.

Guideline Data Sources:

a)  PWQO - Drinking Water.
b)  USEPA - Drinking Water (represents a 0.0001 incremental cancer risk; recommended concentration is 0.
c)  CWQG - Aquatic Life.
d)  PWQO; alternate specification is zero tolerance limit for drinking water.

Reference:  Beak Consultants Limited and Paul Theil Associates Limited, 1991 Study of 1984 Dry Weather Discharges to the Metropolitan Toronto Waterfront, report submitted to the Ontario Ministry of the Environment.

Of the 36 parameters presented, 33 are listed in the Metro Model Sewer Use By-Law. The additional 3 are contained in PWQOs or have a direct aesthetic impact (solvent extractable). Fourteen parameters are cited in the stormwater quality by-law while 19 parameters have numerical values cited in the PWQOs.

The target concentrations show a decrease in the allowable level from the "sanitary sewer system" by-law values through "stormwater system" by-law values to "receiving water" values. The target concentrations listed for sanitary sewers and stormwater systems are for discharges to these sewer systems. The target sanitary sewer concentrations are substantially higher than discharges to storm sewers because sanitary sewerage is treated at wastewater treatment plants whereas stormwater runoff is generally not treated prior to discharge. The target stormwater discharge to storm sewer targets are within a factor of two (2) to five (5) times the PWQOs reflecting the fact that only a modest amount of dilution is available before ambient water conditions required by biota occur. Most of the parameters given in Table 4.6 have targets listed in the PWQOs. Several parameters (TP, phenolics, nitrate, iron, manganese, selenium, silver, total cyanide and arsenic) have PWQO values but do not have target values listed in the stormwater criteria statements.

A parameter by parameter comparison between observed concentrations and PWQO/Sewer Use Bylaw Values (stormsewer) is qualitatively summarized in Table 4.7 for 14 parameters. Generally, wet weather outfall discharge concentrations are lower than sanitary sewer use by-law targets but are generally higher than PWQOs/storm sewer targets for most parameters. For a limited number of parameters, namely nitrate, chromium, selenium, arsenic, and mercury, none of the discharge sources exceed PWQO values.

A qualitative comparison between dry and wet weather storm sewer discharge concentrations is given in Table 4.8. For all parameters listed wet weather concentrations are greater than dry weather concentrations except for TKN, Phenols, Manganese and Arsenic. For eight parameters (BOD,FC, SS, $NO_3$, Aluminum, Copper and Cadmium) the wet weather concentrations exceed dry weather concentration by one order of magnitude. All other contaminant concentrations including most organic parameters exceed dry weather concentrations within an order of magnitude.

A qualitative comparison between the WPCP effluent levels to wet weather storm sewer concentrations is given in Table 4.8. For eight parameters (BOD, FC, SS, aluminum, copper, zinc, alpha BHcard Gamma - BHC) the WPCP concentrations are lower than the wet weather storm sewer concentrations while the WPCP concentrations are higher for two parameters (TKN, nickel and trichlobenzene 1,2,4).

TABLE 4.7:     COMPARISON OF MEASURED VALUES TO
               PWQO AND STORMWATER TARGETS

| Parameter | Wet Weather Storm Sewers | Wet Weather CSOs |
|-----------|:---:|:---:|
| BOD | H | – |
| Fecal Coliforms | H | H |
| SS | H | H |
| TP | H | H |
| Phenolics | H | H |
| Aluminum | H | H |
| Iron | H | H |
| Pb | H | H |
| Ag | H | – |
| Cu | H | H |
| Zn | H | H |
| As | | |
| Cd | H | |
| PCB | * | * |

H = Measured value is higher than storm sewer discharge and/or PWQO target.
* = Detection limit values.
– = Measured values were not available.

TABLE 4.8: COMPARISON OF WPCP EFFLUENT AND DRY WEATHER CONCENTRATIONS CONCENTRATIONS TO WET WEATHER CONCENTRATIONS

| Parameter | Ratio WPCP to Wet Weather Storm | Ratio Dry to Wet Weather Storm |
|---|:---:|:---:|
| BOD | L | L |
| Fecal Coliforms | L | L |
| SS | L | L |
| TP | | L |
| TKN | H | – |
| Phenolics | – | – |
| NO$_3$ | | L |
| Al | L | L |
| Fe | | L |
| Cr | | L |
| Pb | | L |
| Mn | | – |
| Se | | – |
| Cu | L | L |
| Ni | H | L |
| Zn | L | L |
| TCN | – | – |
| As | | H |
| Cd | | L |
| Hg | | L |
| Alpha – BHC | L | – |
| Gamma – BHC | L | L |
| Trichlorobenzene 1,2,4 | H | L |
| Trichlorobenzene 1,2,3 | | L |
| Trichlorobenzene 1,3,5 | | L |

| | | |
|---|---|---|
| L | = | Lower. (<1.0) |
| H | = | Higher (>1.0) |
| Blank | = | Same concentration range. |

For the remaining ten parameters (namely metals), the WPCP effluent concentrations are similar in magnitude to the wet weather stormwater concentrations. Accordingly, for the majority of these parameters, WPCP loadings are much larger than loadings from the storm sewers because the flow rate discharged by the WPCPs is over an order of magnitude larger.

## 5 – ESTIMATED WET WEATHER LOADINGS FOR THE WATERFRONTS

### 5.1 Summary of Contaminant Loadings

In this section, the predicted wet weather loadings for the Etobicoke and Scarborough waterfronts are presented and discussed. As a result of the statistical analyses showing no relationship between EMCs and runoff volumes, the loading estimates which are presented were computed as the product of the estimated AEMCs and the runoff volumes predicted. Tables A.9 (Appendix 2) presents the estimated loadings for each catchment or outfall for the summer/fall period (May to October) and for the winter/spring (November to April) period.

Table 5.1 presents a ranking of the pollutant loadings on a catchment basis. The ranking of wet weather loading from the various catchments is the same as that presented for volumetric discharges (Table 3.5), as the AEMC for each catchment is essentially the same. The following conclusions may be drawn:

- the pollutant loading from each municipality is approximately the same;

- outfall L204 in Etobicoke represents the largest catchment in the study area and is the largest source of pollutant loading for all constituents. This outfall conveys approximately 19 percent of the total annual loading (Scarborough and Etobicoke, collectively) or about 42 percent of the loading from Etobicoke;

- the second highest source of loadings is Catchment E10 or outfall L403C in Etobicoke, followed by Catchment S18 and S6 located in Scarborough. Outfall L904 discharges both storm and combined sewage; and

- all other catchments average approximately 2.1 percent of the total annual loading.

A summary of the wet weather contaminant loadings for each of the Etobicoke and Scarborough waterfronts for each period and per annum is presented in Tables 5.2, 5.3 and 5.4. Loading estimates for the winter/spring period were prepared assuming similar concentrations to those measured during the summer/fall period. The winter/spring period therefore produces the largest loads (approximately 67 percent of the annual load) due to the larger runoff volume relative to the summer/fall period. The

## TABLE 5.1    RANKING OF WATERFRONT CATCHMENTS
## BASED ON WET WEATHER LOADINGS

| CATCHMENT | PERCENT OF TOTAL LOAD | MUNICIPAL OUTFALL NUMBER(S) |
|---|---|---|
| E5 | 19.2 | L203B, L204, L205 |
| E10 | 8.2 | L403C |
| E8 | 6.9 | L308, L309 |
| S18 | 6.8 | 919 |
| S6 | 5.9 | 900 |
| S10 | 5.5 | 903 |
| S12 | 4.0 | 925 |
| S7 | 3.6 | 904 |
| E4 | 3.5 | L201, L202, L203A |
| S9 | 3.5 | 901 |
| S4 | 3.2 | 908 |
| S8 | 3.0 | 918 |
| S11 | 2.8 | 931, 933, 935 |
| S2 | 2.6 | 912 |
| S13 | 2.3 | 913 |
| S16 | 2.2 | 927 |
| S17 | 2.2 | discharges to marsh |
| E11 | 1.9 | L404 |
| E9 | 1.7 | L401, L402, L403 |
| S14 | 1.6 | 911, 909 |
| S15 | 1.6 | 915 |
| S5 | 1.5 | 906 |
| E7 | 1.5 | 02, L303, L304, L305, L306, L307 |
| S1 | 1.3 | 914 |
| S3 | 1.1 | 910 |
| E12 | 0.7 | L405, L406, L407, L408 |
| E1 | 0.6 | L102 |
| E3 | 0.6 | L104, L105 |
| E2 | 0.4 | L103 |
| E6 | 0.3 | L301 |

## TABLE 5.2     SUMMARY OF ESTIMATED SUMMER/FALL LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | SCARBOROUGH STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 1,579,000 | 547,000 | 1,358,000 | 3,484,000 |
| Hardness | kg | 436,000 | 150,800 | 374,800 | 961,600 |
| Phenolics (4AAP) | kg | 35 | 12 | 30 | 77 |
| Total suspended solids | kg | 258,000 | 89,150 | 220,900 | 568,050 |
| Ammonium | kg | 499 | 172 | 430 | 1,101 |
| Nitrates | kg | 6,551 | 2,262 | 5,600 | 14,413 |
| Nitrite | kg | 107 | 37 | 92 | 236 |
| Total Kjeldhal Nitrogen | kg | 5,108 | 1,767 | 4,400 | 11,275 |
| Total Phosphorus | kg | 1,059 | 366 | 900 | 2,325 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 7,868 | 2,726 | 6,760 | 17,354 |
| Fecal Coliform MF | Tcts | 11,270 | 3,903 | 9,700 | 24,873 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 6 | 2 | 5 | 13 |
| Aluminum | kg | 3,489 | 1,207 | 3,000 | 7,696 |
| Arsenic | kg | 2 | 1 | 1 | 4 |
| Barium | kg | 97 | 33 | 83 | 213 |
| Cadmium | kg | 6 | 2 | 5 | 13 |
| Chromium | kg | 29 | 10 | 24 | 63 |
| Copper | kg | 249 | 86 | 210 | 545 |
| Iron | kg | 9,538 | 3,295 | 8,200 | 21,033 |
| Mercury | g | 122 | 42 | 100 | 264 |
| Manganese | kg | 353 | 122 | 300 | 775 |
| Nickel | kg | 22 | 7 | 19 | 48 |
| Lead | kg | 105 | 36 | 90 | 231 |
| Selenium | kg | 2 | 1 | 1 | 4 |
| Zinc | kg | 794 | 129 | 320 | 1,243 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 4,026 | 1,393 | 3,500 | 8,919 |
| Gamma-BHC | mg | 3,073 | 1,063 | 2,600 | 6,736 |
| 1,3,5-Trichlorobenzene | mg | 4,277 | 1,479 | 3,700 | 9,456 |
| 1,2,4-Trichlorobenzene | mg | 9,706 | 3,351 | 8,300 | 21,357 |
| 1,2,3-Trichlorobenzene | mg | 4,356 | 1,508 | 3,700 | 9,564 |
| Hexachlorobenzene | mg | 619 | 229 | 568 | 1,417 |
| PP DDE | mg | 317 | 117 | 291 | 726 |
| Alpha Chlordane | mg | 1,314 | 486 | 1,206 | 3,006 |
| Gamma Chlordane | mg | 1,161 | 429 | 1,066 | 2,657 |
| OP DDT | mg | 614 | 227 | 564 | 1,405 |
| PP DDT | mg | 2,125 | 786 | 1,951 | 4,861 |
| Dieldrin | mg | 1,546 | 572 | 1,420 | 3,537 |
| Hexachloroethane | mg | 349 | 129 | 321 | 799 |
| Hexachlorobutadiene | mg | 626 | 231 | 575 | 1,432 |
| Trichlorotoluene 2-4-5 | mg | 1,610 | 596 | 1,478 | 3,684 |
| Tetrachlorobenzene 1-2-3-5 | mg | 6,308 | 2,333 | 5,791 | 14,432 |
| Trichlorotoluene 2-6-A | mg | 1,482 | 548 | 1,361 | 3,391 |
| Pentachlorobenzene | mg | 1,203 | 445 | 1,104 | 2,752 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 527 | 182 | 450 | 1,159 |
| Acenaphthylene | g | 36 | 12 | 30 | 78 |
| Acenaphthene | g | 179 | 61 | 150 | 390 |
| Fluorene | g | 282 | 97 | 240 | 619 |
| Phenanthrene | g | 2,346 | 811 | 2,000 | 5,157 |
| Anthracene | g | 97 | 33 | 83 | 213 |
| Fluoranthene | g | 3,178 | 1,099 | 2,700 | 6,977 |
| Pyrene | g | 2,139 | 739 | 1,800 | 4,678 |
| Benzo (A) Anthracene | g | 708 | 245 | 600 | 1,553 |
| Chrysene | g | 1,406 | 486 | 1,200 | 3,092 |
| Benzo (B) Fluoranthene | g | 2,284 | 790 | 1,960 | 5,034 |
| Benzo (B-K) Fluoranthene | g | 1,501 | 519 | 1,300 | 3,320 |
| Benzo (A) Pyrene | g | 1,036 | 358 | 900 | 2,294 |
| Indeno (1-2-3 C-D) Pyrene | g | 498 | 172 | 430 | 1,100 |
| Dibenzo (A-H) Anthracene | g | 234 | 81 | 200 | 515 |
| Benzo (G-H-I) Perylene | g | 591 | 204 | 500 | 1,295 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

## TABLE 5.3 SUMMARY OF ESTIMATED WINTER/SPRING LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | SCARBOROUGH STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 3,131,000 | 1,093,000 | 3,488,000 | 7,712,000 |
| Hardness | kg | 864,000 | 302,000 | 962,300 | 2,128,300 |
| Phenolics (4AAP) | kg | 70 | 24 | 77 | 171 |
| Total suspended solids | kg | 510,000 | 178,000 | 568,600 | 1,256,600 |
| Ammonium | kg | 987 | 345 | 1,100 | 2,432 |
| Nitrates | kg | 12,962 | 4,525 | 14,400 | 31,887 |
| Nitrite | kg | 214 | 75 | 240 | 529 |
| Total Kjeldhal Nitrogen | kg | 10,126 | 3,534 | 11,300 | 24,960 |
| Total Phosphorus | kg | 2,099 | 733 | 2,300 | 5,132 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 15,590 | 5,440 | 17,350 | 38,380 |
| Fecal Coliform MF | Tcts | 22,338 | 7,797 | 24,900 | 55,035 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 12 | 4 | 13 | 29 |
| Aluminum | kg | 6,930 | 2,413 | 7,690 | 17,033 |
| Arsenic | kg | 4 | 1 | 3 | 8 |
| Barium | kg | 194 | 68 | 200 | 462 |
| Cadmium | kg | 12 | 4 | 13 | 29 |
| Chromium | kg | 57 | 20 | 60 | 137 |
| Copper | kg | 495 | 172 | 550 | 1,217 |
| Iron | kg | 18,886 | 6,592 | 21,000 | 46,478 |
| Mercury | g | 242 | 85 | 270 | 597 |
| Manganese | kg | 700 | 244 | 760 | 1,704 |
| Nickel | kg | 45 | 15 | 50 | 110 |
| Lead | kg | 210 | 73 | 230 | 513 |
| Selenium | kg | 4 | 1 | 3 | 8 |
| Zinc | kg | 741 | 259 | 830 | 1,830 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 7,977 | 2,786 | 8,890 | 19,653 |
| Gamma-BHC | mg | 6,099 | 2,126 | 6,780 | 15,005 |
| 1,3,5-Trichlorobenzene | mg | 8,479 | 2,955 | 9,440 | 20,874 |
| 1,2,4-Trichlorobenzene | mg | 19,217 | 6,701 | 21,390 | 47,308 |
| 1,2,3-Trichlorobenzene | mg | 8,646 | 3,021 | 9,620 | 21,287 |
| Hexachlorobenzene | mg | 1,238 | 458 | 1,137 | 2,833 |
| PP DDE | mg | 635 | 235 | 583 | 1,452 |
| Alpha Chlordane | mg | 2,628 | 972 | 2,412 | 6,012 |
| Gamma Chlordane | mg | 2,323 | 859 | 2,133 | 5,314 |
| OP DDT | mg | 1,228 | 454 | 1,127 | 2,809 |
| PP DDT | mg | 4,249 | 1,571 | 3,901 | 9,722 |
| Dieldrin | mg | 3,092 | 1,144 | 2,839 | 7,075 |
| Hexachloroethane | mg | 698 | 258 | 641 | 1,598 |
| Hexachlorobutadiene | mg | 1,252 | 463 | 1,149 | 2,864 |
| Trichlorotoluene 2-4-5 | mg | 3,221 | 1,191 | 2,957 | 7,369 |
| Tetrachlorobenzene 1-2-3-5 | mg | 12,615 | 4,665 | 11,582 | 28,863 |
| Trichlorotoluene 2-6-A | mg | 2,965 | 1,096 | 2,722 | 6,783 |
| Pentachlorobenzene | mg | 2,406 | 890 | 2,209 | 5,504 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 1,055 | 365 | 1,160 | 2,580 |
| Acenaphthylene | g | 73 | 25 | 80 | 178 |
| Acenaphthene | g | 358 | 124 | 390 | 872 |
| Fluorene | g | 565 | 195 | 620 | 1,380 |
| Phenanthrene | g | 4,694 | 1,623 | 5,170 | 11,487 |
| Anthracene | g | 195 | 67 | 220 | 482 |
| Fluoranthene | g | 6,355 | 2,198 | 7,000 | 15,553 |
| Pyrene | g | 4,278 | 1,480 | 4,720 | 10,478 |
| Benzo (A) Anthracene | g | 1,416 | 490 | 1,560 | 3,466 |
| Chrysene | g | 2,812 | 972 | 3,100 | 6,884 |
| Benzo (B) Fluoranthene | g | 4,569 | 1,580 | 5,040 | 11,189 |
| Benzo (B-K) Fluoranthene | g | 3,003 | 1,038 | 3,310 | 7,351 |
| Benzo (A) Pyrene | g | 2,072 | 717 | 2,280 | 5,069 |
| Indeno (1-2-3 C-D) Pyrene | g | 996 | 344 | 1,100 | 2,440 |
| Dibenzo (A-H) Anthracene | g | 469 | 162 | 520 | 1,151 |
| Benzo (G-H-I) Perylene | g | 1,184 | 409 | 1,300 | 2,893 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

## TABLE 5.4 SUMMARY OF ESTIMATED ANNUAL LOADINGS

| PARAMETER | UNITS | ETOBICOKE STORM | SCARBOROUGH CSO | STORM | TOTAL |
|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | |
| Chemical Oxygen Demand | kg | 4,710,000 | 1,640,000 | 4,846,000 | 11,196,000 |
| Hardness | kg | 1,300,000 | 452,800 | 1,337,100 | 3,089,900 |
| Phenolics (4AAP) | kg | 105 | 36 | 107 | 248 |
| Total suspended solids | kg | 768,000 | 267,150 | 789,500 | 1,824,650 |
| Ammonium | kg | 1,486 | 517 | 1,530 | 3,533 |
| Nitrates | kg | 19,513 | 6,787 | 20,000 | 46,300 |
| Nitrite | kg | 321 | 112 | 332 | 765 |
| Total Kjeldhal Nitrogen | kg | 15,234 | 5,301 | 15,700 | 36,235 |
| Total Phosphorus | kg | 3,158 | 1,099 | 3,200 | 7,457 |
| **BACTERIOLOGY** | | | | | |
| E-Coli | Tcts | 23,458 | 8,166 | 24,110 | 55,734 |
| Fecal Coliform MF | Tcts | 33,608 | 11,700 | 34,600 | 79,908 |
| **HEAVY METALS** | | | | | |
| Silver | kg | 18 | 6 | 18 | 42 |
| Aluminum | kg | 10,419 | 3,620 | 10,690 | 24,729 |
| Arsenic | kg | 6 | 2 | 4 | 12 |
| Barium | kg | 291 | 101 | 283 | 675 |
| Cadmium | kg | 18 | 6 | 18 | 42 |
| Chromium | kg | 86 | 30 | 84 | 200 |
| Copper | kg | 744 | 258 | 760 | 1,762 |
| Iron | kg | 28,424 | 9,887 | 29,200 | 67,511 |
| Mercury | g | 364 | 127 | 370 | 861 |
| Manganese | kg | 1,053 | 366 | 1,060 | 2,479 |
| Nickel | kg | 67 | 22 | 69 | 158 |
| Lead | kg | 315 | 109 | 320 | 744 |
| Selenium | kg | 6 | 2 | 4 | 12 |
| Zinc | kg | 1,535 | 388 | 1,150 | 3,073 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | |
| Alpha-BHC | mg | 12,003 | 4,179 | 12,390 | 28,572 |
| Gamma-BHC | mg | 9,172 | 3,189 | 9,380 | 21,741 |
| 1,3,5-Trichlorobenzene | mg | 12,756 | 4,434 | 13,140 | 30,330 |
| 1,2,4-Trichlorobenzene | mg | 28,923 | 10,052 | 29,690 | 68,665 |
| 1,2,3-Trichlorobenzene | mg | 13,002 | 4,529 | 13,320 | 30,851 |
| Hexachlorobenzene | mg | 1,858 | 687 | 1,705 | 4,250 |
| PP DDE | mg | 952 | 352 | 874 | 2,179 |
| Alpha Chlordane | mg | 3,941 | 1,458 | 3,619 | 9,018 |
| Gamma Chlordane | mg | 3,484 | 1,288 | 3,199 | 7,971 |
| OP DDT | mg | 1,842 | 681 | 1,691 | 4,214 |
| PP DDT | mg | 6,374 | 2,357 | 5,852 | 14,584 |
| Dieldrin | mg | 4,638 | 1,715 | 4,259 | 10,612 |
| Hexachloroethane | mg | 1,047 | 387 | 962 | 2,396 |
| Hexachlorobutadiene | mg | 1,878 | 694 | 1,724 | 4,296 |
| Trichlorotoluene 2-4-5 | mg | 4,831 | 1,787 | 4,435 | 11,053 |
| Tetrachlorobenzene 1-2-3-5 | mg | 18,923 | 6,998 | 17,374 | 43,295 |
| Trichlorotoluene 2-6-A | mg | 4,447 | 1,644 | 4,083 | 10,174 |
| Pentachlorobenzene | mg | 3,608 | 1,334 | 3,313 | 8,256 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | |
| Naphthalene | g | 1,582 | 547 | 1,610 | 3,739 |
| Acenaphthylene | g | 109 | 37 | 110 | 256 |
| Acenaphthene | g | 537 | 185 | 540 | 1,262 |
| Fluorene | g | 847 | 292 | 860 | 1,999 |
| Phenanthrene | g | 7,040 | 2,434 | 7,170 | 16,644 |
| Anthracene | g | 292 | 100 | 303 | 695 |
| Fluoranthene | g | 9,533 | 3,297 | 9,700 | 22,530 |
| Pyrene | g | 6,417 | 2,219 | 6,520 | 15,156 |
| Benzo (A) Anthracene | g | 2,124 | 735 | 2,160 | 5,019 |
| Chrysene | g | 4,218 | 1,458 | 4,300 | 9,976 |
| Benzo (B) Fluoranthene | g | 6,853 | 2,370 | 7,000 | 16,223 |
| Benzo (B-K) Fluoranthene | g | 4,504 | 1,557 | 4,610 | 10,671 |
| Benzo (A) Pyrene | g | 3,108 | 1,075 | 3,180 | 7,363 |
| Indeno (1-2-3 C-D) Pyrene | g | 1,494 | 516 | 1,530 | 3,540 |
| Dibenzo (A-H) Anthracene | g | 703 | 243 | 720 | 1,666 |
| Benzo (G-H-I) Perylene | g | 1,775 | 613 | 1,800 | 4,188 |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams

largest loading events likely occur for 2 or 3 major rainfall/snowmelt events in March and April. This is suggested by the historical flow records which show the largest volume of flow for these two months, see Figure 3.5. Similarly, during the summer/fall period, the major loading events will occur for a few large events. This was illustrated in Figure 3.2 and Table 3.7, where 50 percent of the summer/fall seasonal runoff volume occurs over six runoff events ranging between 18 and 37 mm.

## 5.2 Comparison of Wet and Dry Weather Loadings

A presentation is provided in Table 5.5 comparing wet weather discharge loadings from Scarborough and Etobicoke to dry weather discharges prepared for the Etobicoke, Toronto and Scarborough Waterfront in a companion study (BEAK and Theil, 1991). In general, the wet weather loads exceed or are within the same order of magnitude of dry weather loads for most parameters. Wet weather bacterial loads exceed dry weather loads by as much as 3 orders of magnitude. Nine parameters (TSS, Cadmium, Mercury, Selenium, Fluoranthene, Pyrene, Chrysene, 1,2,3-Trichlorobenzene and 1,3,5-Trichlorobenzene) exceed dry weather loads by 2 order of magnitude. Eight parameters (TP, Iron, Lead, Nickel, Arsenic, Anthracene, Benzo (a) Anthracene and 1,2,4-Trichlorobenzene) exceed dry weather loads by 1 order of magnitude.

Intuitively one would expect wet weather loads to exceed dry weather loads due to significantly higher discharge volumes. For the Metro Toronto waterfront, dry weather discharge volumes computed for all outfalls across the waterfront were found to be similar to wet weather volumes for waterfront outfalls in the cities of Etobicoke and Scarborough (BEAK and Theil, 1991). Average dry and wet weather discharges are 32 and 37.5 million litres per day (MLD) respectively.

The higher loads are attributed to higher concentrations, see Section 4.7. Dry weather loads will be further exceeded by wet weather loads when contributions from the City of Toronto Waterfront (Phase II study) have been added to loads from Etobicoke and Scarborough.

## 5.3 Comparison of Wet Weather Outfall and Main WPCP Bypass Loads

Presented in Table 5.6 is a comparison of the wet weather outfall loads to loads from the Main WPCP bypass. Ten parameters from the general chemistry, bacteriological and heavy metal groups (COD, TSS, Nitrates, Nitrites, Aluminum, Copper, Manganese, Nickel, Lead, Zinc) have wet weather outfall loadings which exceed the Main WPCP bypass loadings. Three of the 10 parameters (COD, Nitrates,

TABLE 5.5:     WET AND DRY WEATHER LOADING ESTIMATES IN 1989 FOR WATERFRONT OUTFALLS

| Parameter | Units | Dry Weather | Wet Weather Scarborough /Etobicoke | Ratio Wet/Dry |
|---|---|---|---|---|
| **Conventional Parameters** | | | | |
| TSS | kg/d | 815 | 26,244 | H |
| TKN | kg/d | 62.6 | 85 | |
| Nitrates | kg/d | 146 | 109 | |
| TP | kg/d | 9.53 | 18 | H |
| **Bacteria** | | | | |
| Fecal Coliforms | $10^{12}$counts/d | 0.573 | 131 | H |
| E. Coli | $10^{12}$counts/d | 0.539 | 187 | H |
| **Metals** | | | | |
| Aluminum | g/d | 15900 | 5800 | |
| Barium | g/d | 3540 | 2000 | |
| Cadmium | g/d | 3.15 | 103 | H |
| Chromium | g/d | 529 | 483 | |
| Copper | g/d | 2810 | 4000 | H |
| Iron | g/d | 42800 | 158000 | H |
| Lead | g/d | 517 | 2000 | H |
| Manganese | g/d | 7390 | 6000 | |
| Mercury | g/d | 0.016 | 2 | H |
| Nickel | g/d | 10.8 | 379 | H |
| Zinc | g/d | 2750 | 7000 | H |
| Arsenic | g/d | 3.02 | 34 | H |
| Selenium | g/d | 0.830 | 35 | H |
| **General Organics** | | | | |
| Phenol | kg/d | 0.251 | 0.59 | |
| **BHC** | | | | |
| Alpha–BHC | mg/d | 47 | 67 | |
| Gamma–BHC | mg/d | 23 | 51 | |
| **PAH** | | | | |
| Anthracene | g/d | 0.690 | 2.0 | H |
| Fluoranthene | g/d | 0.690 | 53.0 | H |
| Pyrene | g/d | 0.690 | 36.0 | H |
| Benzo(a)Anthracene | g/d | 1.26 | 12.0 | H |
| Chrysene | g/d | 0.640 | 23.0 | H |
| **Other Organics** | | | | |
| 1,2,3–Trichlorobenzene | mg/d | 0.328 | 72 | H |
| 1,2,4–Trichlorobenzene | mg/d | 50.4 | 161 | H |
| 1,3,5–Trichlorobenzene | mg/d | 0.315 | 63.7 | H |

kg/d – kilograms/day    g/d – grams/day    mg/d – milligrams/day    H – High    L– Low

## TABLE 5.6 — COMPARISON OF ANNUAL WET WEATHER OUTFALL AND MAIN WPCP BYPASS LOADS

| PARAMETER | UNITS | OUTFALLS | MAIN WPCP BYPASS | RATIO OUTFALLS/BYPASS |
|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | |
| Chemical Oxygen Demand | kg | 11,196,000 | 170,000 | H |
| Hardness | kg | 3,089,900 | -------- | |
| Phenolics (4AAP) | kg | 248 | 100 | |
| Total suspended solids | kg | 1,824,650 | 247,000 | H |
| Ammonium | kg | 3,533 | 19,900 | L |
| Nitrates | kg | 46,300 | 30 | H |
| Nitrite | kg | 765 | 10 | H |
| Total Kjeldhal Nitrogen | kg | 36,235 | 39,700 | |
| Total Phosphorous | kg | 7,457 | 11,100 | L |
| **BACTERIOLOGY** | | | | |
| E-Coli | Tcts | 55,734 | 32,000 | |
| Fecal Coliform MF | Tcts | 79,908 | 40,600 | |
| **HEAVY METALS** | | | | |
| Silver | kg | 42 | 60 | |
| Aluminum | kg | 24,729 | 2,100 | H |
| Arsenic | kg | 12 | -------- | |
| Barium | kg | 675 | 200 | |
| Cadmium | kg | 42 | 10 | |
| Chromium | kg | 200 | 200 | |
| Copper | kg | 1,762 | 300 | H |
| Iron | kg | 67,511 | 22,000 | |
| Mercury | g | 861 | 400 | |
| Manganese | kg | 2,479 | 100 | H |
| Nickel | kg | 158 | 40 | H |
| Lead | kg | 744 | 90 | H |
| Selenium | kg | 12 | -------- | |
| Zinc | kg | 3,073 | 500 | H |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | |
| Alpha-BHC | mg | 28,572 | 400 | H |
| Gamma-BHC | mg | 21,741 | 1,500 | H |
| 1,3,5-Trichlorobenzene | mg | 30,330 | 100 | H |
| 1,2,4-Trichlorobenzene | mg | 68,665 | 3,500 | H |
| 1,2,3-Trichlorobenzene | mg | 30,851 | ND | |
| Hexachlorobenzene | mg | 4,250 | 300 | H |
| PP DDE | mg | 2,179 | 200 | H |
| Alpha Chlordane | mg | 9,018 | 200 | H |
| Gamma Chlordane | mg | 7,971 | 100 | H |
| OP DDT | mg | 4,214 | 100 | H |
| PP DDT | mg | 14,584 | 300 | H |
| Dieldrin | mg | 10,612 | 200 | H |
| Hexachloroethane | mg | 2,396 | 100 | H |
| Hexachlorobutadiene | mg | 4,296 | ND | |
| Trichlorotoluene 2-4-5 | mg | 11,053 | ND | |
| Tetrachlorobenzene 1-2-3-5 | mg | 43,295 | 600 | H |
| Trichlorotoluene 2-6-A | mg | 10,174 | 100 | H |
| Pentachlorobenzene | mg | 8,256 | 1,000 | H |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | |
| Napthalene | g | 3,739 | 100 | H |
| Acenapthylene | g | 256 | 3 | H |
| Acenapthene | g | 1,262 | 100 | H |
| Fluorene | g | 1,999 | 200 | H |
| Phenanthrene | g | 16,644 | 500 | H |
| Anthracene | g | 695 | 20 | H |
| Fluoranthene | g | 22,530 | 600 | H |
| Pyrene | g | 15,156 | 600 | H |
| Benzo (A) Anthracene | g | 5,019 | 30 | H |
| Chrysene | g | 9,976 | 40 | H |
| Benzo (B) Fluoranthene | g | 16,223 | 8 | H |
| Benzo (B-K) Fluoranthene | g | 10,671 | 8 | H |
| Benzo (A) Pyrene | g | 7,363 | 7 | H |
| Indeno (1-2-3 C-D) Pyrene | g | 3,540 | ND | |
| Dibenzo (A-H) Anthracene | g | 1,666 | ND | |
| Benzo (G-H-I) Perylene | g | 4,188 | ND | |

Tcts - Tetra counts (10^12)  T - Tonnes  kg - kilograms  g - grams  mg - milligrams  H - High  L - Low  ND - Not Detected

Nitrites) have concentrations in wet weather discharges which exceeded the WPCP discharges, therefore the primary cause for higher outfall loadings is due to discharge volume and concentration.

All sewer outfall loadings for organochlorine pesticides, chlorobenzenes and PAH's exceed loadings from the WPCP bypass by 1 to 3 orders of magnitude. The higher loadings are attributed to higher volumes and concentrations in stormwater runoff.

The Main WPCP bypass discharges annual loadings which exceed outfall loads by one order of magnitude for Ammonium and Total Phosphorus. Furthermore the bypass discharges loadings of Phenolics, TKN, bacteria, Silver, Barium, Iron, Chromium and Mercury are within the same order of magnitude as outfall loadings. The cause for these relative loading conditions is due to significantly higher concentrations in bypass flow, see Section 4.6 and lower discharge volumes (5 percent of sewer outfalls).

In summary, the Main WPCP bypass, which is physically a single discharge source, servicing a relatively larger drainage area, with relatively lower discharge volumes may contribute loadings of Ammonium and Total Phosphorus, some heavy metals, and bacteria which are equal to or greater than all sewer outfalls discharging to the Waterfront from Etobicoke and Scarborough under wet weather conditions. Organchlorine pesticides , chlorobenzene and PAH loadings are less than storm sewer outfall loadings by 1 to 3 orders of magnitude.

## 6 – SUMMARY AND CONCLUSIONS

### 6.1 General Summary

This study has presented estimates of wet weather contaminant loadings from urban runoff for storm and combined sewers which discharge directly to the Etobicoke and Scarborough waterfronts. The loadings have been prepared and summarized for 60 water quality parameters from the following water chemistry groups.

- General Chemistry;
- Bacteriological;
- Heavy Metals;
- Organochlorine Pesticides/PCB/Chlorobenzenes; and
- Polynuclear Aromatic Hydrocarbons.

The study was comprised of the following tasks:

- a field monitoring program; and
- a modelling exercise to estimate outfall discharge volumes and contaminant loadings.

The field program involved the collection of flow volumes and constituent concentrations at seven representative storm outfalls, two combined sewer outfalls and the Berry Street combined sewer overflow and Metro's Main WPCP Primary Treatment Bypass. The data collected in the field program was then used as a basis to estimate flow volumes and pollutant loadings from each of the 28 waterfront sewersheds in Etobicoke and 18 waterfront sewersheds in Scarborough.

The following procedure was then used to estimate constituent loadings for each of the 88 parameters which were considered:

- the field data was summarized based on flow volume (i.e., the total runoff volume for a given event or period) and Event Mean Concentration (i.e., the mean concentration of the constituent over the sampling period);

- the sewersheds were categorized based on the dominant land use type;

–    the probability distribution function was determined for water chemistry data sets representative of a given land use;

–    the Average Event Mean Concentration (AEMC) for each land use was calculated using either the Maximum Likelihood Estimation (MLE) method, or substituting one half the detection limit value for all censored data or a linear regression fit on a probability plot;

–    AEMCs were compared by land use, and by discharge type (storm/CSO and storm/WPCP bypass);

–    volumes of discharge were predicted for the typical summer/fall rainfall conditions using continuous simulation and the Stormwater Management Computer Model (SWMM). The use of historical rainfall data and continuous simulation techniques provided for a reasonable prediction of discharge volumes. Rainfall data for the year 1980 was determined to be representative of average summer/fall conditions. Winter/spring volumes were estimated using a simplified mass balance approach; and

–    contaminant loadings were prepared on a seasonal and annual basis for several waterfront catchments as the product of the AEMC and the runoff volume predicted.

The loadings have been provided using the following formats:

–    by catchment area (municipal sewer outfall);
–    by municipality;
–    by sewerage type (storm sewer and storm sewers which CSO);
–    by season (summer/fall and winter/spring); and
–    by typical rainfall year.

## 6.2      Statements

The following statements have been prepared based on data, analytical results and the computations prepared in this study.

1.  This study has collected and documented the first data set for wet weather runoff water quantity and quality from all storm sewer outfalls discharging directly to the Etobicoke and Scarborough waterfronts. The data sets represent discharges from several sites representative of principal land uses, including residential, commercial and industrial. Data was also collected for wet weather discharges which contained combined sewer overflow (CSO) and for the Main WPCP bypass effluent under runoff conditions. The data sets provide a detailed characterization of contaminant concentration including nutrients, bacteria, heavy metals and trace organic compounds (organochlorine pesticides, chlorobenzenes, PCBs and polynuclear aromatic hydrocarbons).

2.  Low level analytical techniques were used to measure concentrations of trace organic compounds. This entailed using solvent extraction procedures on larger sample volumes (16 litres) than normally used (1 litre). This procedure has resulted in improving the detection limit by an order of magnitude over normal techniques.

3.  Of the 88 water quality parameters tested, all were detected in wet weather discharges to the Etobicoke and Scarborough waterfronts. Heavy metals were in general detected in more than 80 percent of the samples. Many trace organic compounds were identified in most of the wet weather samples.

    Trace organic substances which were detected in more than 50 percent of the samples include:

    | Contaminant | Frequency of Detection (%) |
    |---|---|
    | • phenols | 100 |
    | • Alpha BHC | 100 |
    | • Gamma BHC | 96 |
    | • 1,2,3,5-Tetrachlorobenzene | 73 |
    | • Dieldrin | 63 |
    | • Hexachlorobutadiene | 63 |
    | • Pentachlorobenzene | 63 |
    | • Hexachloroethane | 57 |
    | • 1,2,4-Trichlorobenzene | 57 |
    | • 26A-Trichlorotoluene | 57 |
    | • 1,3,5-Trichlorobenzene | 51 |

All PAHs listed below were detected for 60 to 100 percent of the samples.

| Substance | Frequency of Detection (%) |
|---|---|
| Naphthalene | 100 |
| Acenaphthylene | 75 |
| Acenaphthene | 94 |
| Fluorene | 94 |
| Phenanthrene | 98 |
| Anthracene | 88 |
| Fluoranthene | 100 |
| Pyrene | 100 |
| Benzo (A) Anthracene | 94 |
| Chrysene | 96 |
| Benzo (B) Fluoranthene | 87 |
| Benzo (B–K) Fluoranthene | 85 |
| Benzo (A) Pyrene | 83 |
| Indeno (1–2–3 C–D) Pyrene | 79 |
| Dibenzo (A–H) Anthracene | 60 |
| Benzo (G–H–I) Perylene | 81 |

Total PCBs were detected in 10 percent of the samples.

The frequency of detected trace organics in wet weather discharges exceeds those measured in dry weather sewer outfall discharges (BEAK and Theil, 1991).

4.  The concentration of conventional parameters, heavy metals, organochlorine pesticides and PAHs have been compared to levels specified in the Model Sewer Use By–Laws Provincial Water Quality Objectives (PWQOs) and Canadian Water Quality Guidelines (CWQGs). In general, wet weather discharges were found to be in exceedance of those levels specified in the by–laws and objectives for BOD, Fecal Coliforms, Total Suspended Solids, Total Phosphorus, Phenolics, Aluminum, Iron, Lead, Silver, Copper, Zinc and Cadmium.

5.  Outfall concentrations have been compared under dry and wet weather conditions. The results show that wet weather concentrations are larger than dry weather concentrations. Wet weather concentrations are significantly higher by an order of magnitude for BOD, Fecal Coliform, Suspended Solids, Nitrates, Aluminum, Copper and Cadmium.

6.  Statistical analysis of the water quality data shows that there is no significant relationship between the Event Mean Concentration (EMC) and the outfall discharge volume. This allows for the calculation of contaminant loading as the product of the average EMC (AEMC) and event runoff volume.

7.  The statistical analysis showed that the AEMC is independent of land use type. The lack of difference between the AEMCs between the different land uses may, in part, be due to such items as atmospheric contamination being uniformly distributed over the area and the land use patterns within the study area (i.e., a direct comparison of distinct land uses was not possible as all commercial and industrial sewersheds contained some residential lands).

8.  Comparison of the AEMC from stormwater discharges, stormwater discharges which contained CSO and the Main WPCP bypass indicated the following:

    –   Contaminant concentrations generally show no significant difference between discharges of stormwater runoff and stormwater runoff containing CSO for all parameter groups except bacterial. This is due to high levels of sewer separation within the combined sewer systems resulting in minimal quantities of CSO discharging into the storm sewer system;

    –   stormwater discharges containing small quantities of CSO showed consistent but marginally higher concentrations for four bacterial parameters; and

    –   the Main WPCP bypass showed significantly higher concentrations usually by as much as an order of magnitude for most parameters in each parameter group with the greatest differences occurring for Ammonia, Total Phosphorus and bacteria.

9.  Water quality concentrations for outfalls containing CSO were considerably lower than those reported in literature data (NURP, TAWMS, UGLCCS). These lower concentrations are attributed to the high degree of sewer separation which has occurred within the combined sewer areas.

Water quality concentrations for outfalls not containing CSO were within the range or within an order of magnitude of those observed in other Ontario and United States Studies.

10.     The distribution of precipitation over a year is fairly uniform. However, literature and stream flow data for several local watersheds suggested that runoff volumes for the winter/spring period are approximately twice those occurring for the same quantity of rainfall for the summer/fall period.  This finding was used as the basis for estimating winter runoff volumes and loadings.

The distribution of rainfall/runoff from event to event varies significantly.  For example, the 7 largest rainfall events (7 of 66) during the summer/fall period generate in approximately 50 percent of the runoff volume.  The Metro Main WPCP however, services a much larger sewerage area of 26570 ha.  This area is approximately seven times greater than the Etobicoke and Scarborough waterfront drainage area.

11.     When compared to dry weather discharges, wet weather loadings from sewer outfalls are a significant source of bacteria, heavy metals and organic contaminants.  Wet weather loadings to the Etobicoke and Scarborough waterfronts compared to dry weather loadings for the Etobicoke, Toronto and Scarborough waterfront are found to be:

–     3 orders of magnitude higher for bacteria;

–     2 orders of magnitude higher for Total Suspended Solids, Cadmium, Mercury, Selenium, Fluoranthene, Pyrene, Chrysene, 1,2,3-Trichlorobenzene and 1,3,5-Trichlorobenzene; and

–     1 order of magnitude higher for Total Phosphorus, Iron, Lead, Nickel, Arsenic, Anthracene, Benzo(a)Anthracene and 1,2,4-Trichlorobenzene.

The annual dry weather discharge volume from all waterfront outfalls is about the same as the wet weather volume from the Etobicoke and Scarborough waterfront outfalls. Therefore, the primary cause of the higher loadings is attributed to higher wet weather concentrations.

12. The total average annual volume of urban runoff discharging directly to the Etobicoke and Scarborough waterfronts is 12.6 million cubic metres. Two thirds of this volume discharges in the winter/spring period (November to April) and one third discharges in the summer/fall period (May to October). Twenty percent (2.1 million cubic metres) contains some quantity of CSO. The distribution of runoff volume between municipalities is approximately equal, 49 and 51 percent for Etobicoke and Scarborough, respectively.

13. Fifty percent of the total annual runoff volume originates from 6 of the 46 outfalls. Outfall L204 located in Etobicoke is the single largest discharger of urban runoff to the waterfront. Runoff from this sewershed accounts for 19 percent of the annual volume. The large volume of runoff is attributable to two factors; the catchment area (380 ha) and the high degree of impervious surfaces.

The wet weather loadings for a given catchment are directly related to the volume of runoff as the loadings were calculated based on the AEMC, and flow volume. Thus, the six largest catchments (outfalls L204, L403C, L308 and L309 in Etobicoke, and 919, 904 and 903 in Scarborough) contribute 50 percent of the annual loadings. On average, the remaining catchment areas each contribute about 2 percent of the annual loading.

The annual discharge volume from the Metro Main WPCP bypass is approximately 5 percent of the annual discharge from all of the Etobicoke and Scarborough waterfront outfalls.

14. The Main WPCP bypass, a single discharge source may contribute loadings of Ammonium and Total Phosphorus in excess of wet weather loads from all waterfront outfalls discharging from Etobicoke and Scarborough. Furthermore the bypass discharge loadings of Phenolics, TKN, bacteria, Silver, Barium, Iron, Chromium and Mercury which are within the same order of magnitude as outfall loadings. The higher loading is attributed to significantly higher concentrations in bypass flows compared to sewer outfall discharges. Bypass loadings of toxic organic parameters and PAH's are less than the loadings from sewer outfalls except for Pentachlorobenzene which exceeds outfall loads by an order of magnitude.

15.  The contaminant concentrations and estimated loadings as provided in Appendix 4 may be used to set priorities for remediating storm sewer wet weather discharges to the Etobicoke and Scarborough waterfronts.

16.  Priorities for future studies should include:

- additional sampling of wet weather discharges which contain CSO;

- sampling of runoff occurrences during winter, spring and summer conditions to assess the temporal variability of water quality concentrations due to seasonal variations;

- measurement of urban runoff quantities, particularly during winter and spring runoff occurrences to provide estimates of runoff volume during these seasons. This would provide a database for detailed rainfall–runoff simulation models to predict wet weather discharges for the full range of rainfall and snowmelt conditions which occur in a typical year; and

- assess the impact of the sewer outfall and WPCP bypass sources on the receiving water including a detailed evaluation of sediments quality and the benthic community. Priority should be given to waterfront areas adjacent to the six largest outfalls.

# 7  –  REFERENCES

Beak Consultants Limited, 1987.
    Volume (i):  BEAK, Canviro, Ecologistics and Gore & Storrie (1987) Toronto Western Waterfront Summary – Sources and Loadings.  Report for Toronto RAP Work Team.
    Volume (ii):  BEAK, Canviro, Ecologistics and Gore & Storrie Toronto Eastern Waterfront Summary.  Report for Toronto RAP Work Team.

Beak Consultants Limited and Paul Theil Associates Limited, 1991.  Study of 1989 Dry Weather Discharges to the Metropolitan Toronto Waterfront.  Report Submittted to the Ontario Ministry of the Environment.

Buttle, J.M. and F. Xu, 1988.   Snowmelt Runoff in Suburban Environments.   Nordic Hydrology, 19, 19–40.

Cheung, P., 1990.  Personal Communication.

D'Andrea, M., 1992, Ministry of the Environment, Water Resources Branch, Great Lakes Section, Personal Communications.

Driscoll, E.D., 1986.   Combined Sewer Overflow Analysis Methodology. Woodward–Clyde Consultants, Oakland, NJ.

Environment Canada, Water Survey of Canada, 1989.   Historical Streamflow Summary, Ontario.

Environment Canada, Environment Ontario, Ontario Ministry of Natural Resources and Metropolitan Toronto and Region Conservation Authority, 1988.  Metro Toronto Remedial Action Plan.  Environmental Conditions and Problem Definition.  Executive Summary.

Environment Canada and Atmospheric Environment Service.   Canadian Climate Normals, 1951–1980, Temperature and Precipitation.

Environment Ontario, 1989. Strategy for Improvement of Don River Water Quality. Supporting Document 1.

ISCO Inc. 1986. ISCO 2700 Sampler Instruction Manual.

MacLarens, 1989. Measurement of Pollutant Loadings From Tributaries Discharging to Lake Ontario Metro Toronto Waterfront.

Marsalek, J. and H. Schroeter, 1984. Loadings of Selected Toxic Substances in Urban Runoff in the Canadian Great Lakes Basin. National Water Research Institute, Canada Centre for Inland Water, Burlington, Ontario.

Marsalek, J. and H.Y.F. Ng, 1987. Contaminants in Urban Runoff in the Upper Great Lakes Connecting Channels Area. National Water Reserach Institute, Canada Centre for Inland Water, Burlington, Ontario.

Montedoro–Whitney, 1988. Data Processing Program Instruction Manual.

Nationwide Urban Runoff Program (NURP), 1983. Final Report, Water Planning Division, U.S. Environmental Protection Agency.

Ontario Ministry of Agriculture and Food. Soil Map of York County, 1955.

Ontario Ministry of the Environment, 1988. MOE Analytical Methods.

Ontario Ministry of the Environment, 1986. Humber River Water Quality Management Plan, Toronto Area Watershed Management Strategy Study.

Proctor and Redfern Limited, 1987. City of Scarborough Pollution Control Strategy.

UMA Engineering Ltd., 1989. Study of Metropolitan Toronto Don Trunk Sewer Systems and Main Treatment Plant. The Municipality of Metropolitan Toronto Works Department.

U.S. Environmental Protection Agency, 1989. Stormwater Management Model, Version 4.04.

APPENDIX 1

## TABLE A1.1: WATER QUALITY PARAMETER LIST

---

General Chemistry/Heavy Metals

---

Ammonia - Total Filtered Reactive
Total Kjeldahl Nitrogen
Total Phosphorus
Total Dissolved Solids
Total Suspended Solids
Total Solids
Dissolved Organic Carbon
Chemical Oxygen Demand
Total BOD5
Total Cl2
Chloride
Cyanide
Hydrogen Sulphide
Oil and Grease Extractions
Phenolics - Unfiltered Reactive
Hardness
Nitrates
Nitrites
Alkalinity
Total Cd
Total Cr
Total Cu
Total Fe
Total Hg
Total Mn
Total Ni
Total Pb
Total Zn
Total Al
Total As
Total Ba
Total Ag
Total Se
Total Sn

---

## TABLE A1.1:     WATER QUALITY PARAMETER LIST

---

Organiochloride Pesticides/Chlorobenzenes/PCBs

---

PCB
HCB
Heptachlor
Aldrin
pp DDE
Mirex
Alpha BHC
Gamma BHC
Beta BHC
Alpha Chlordane
Gamma Chlordane
op DDT
pp DDT
pp DDD
Heptachlor Epoxide
Thiodan I
Thiodan II
Thiodan Sulphate
Dieldrin
Endrin
Oxychlordane
Methoxychlor
Hexachloroethane
1,3,5-Trichlorobenzene
1,2,4-Trichlorobenzene
1,2,3-Trichlorobenzene
Hexachlorobutadiene
2,4,5-Trichlorotoluene
2,3,6-Trichlorotoluene
1,2,4,5-Tetrachlorobenzene
1,2,3,5-Tetrachlorobenzene
26A Trichlorotoluene
1,2,3,4-Tetrachlorobenzene
Pentachlorobenzene
Octachlorostyrene

---

TABLE A1.1:        WATER QUALITY PARAMETER LIST

---

Bacteriology

---

Fecal Coliform
Pseudomonas Aeruginosa
Escherichia Coliform
Fecal Streptococcus

---

Polynuclear Aromatic Hydrocarbons

---

Napthalene
Benzo(a)pyrene
Benzo(ghi)perylene
Dibenzo(ah)anthracene
Indeno(1,2,3-cd)pyrene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benz(a)anthracene
Chrysene
Benzo(b)fluoranthene
Acenopthylene
Acenapthene
Fluorene
Benzo(B-K)Flourathene

---

# SAMPLE CONTAINER
# CLEANING PROCEDURES AND PROTOCOLS

## BOTTLES

### 4 Litre Organic

- Solvent Rinse with Hexane

### 23 Litre Sample Collection Bottles

- Soap and hot water
- Rinse with hot water
- Rinse with distilled water
- Rinse with 10% nitric acid
- Rinse with distilled water
- Rinse with acetone
- Rinse with hexane
- Temporary caps of hexane rinsed aluminum foil were used

## SAMPLERS

- Hexane Rinse.

```
───────────────────────── QBase ──────────────────────────
───────────────── Datalogger setup ──────────────────
    ID: 32                    Instrument:   PV Q-Logger depth, velocity
Comment: second street north of pumping station site #3 upstream

   Probe: Type 2 (5 psi)     Depth: cm      Depth offset:        0.00 cm
Direction: Upstream           Velocity: m/s        Interval:  5 min
                                                    Memory: Wraparound

            Equation:   Point velocity (round pipe)
                Flow:  l/s

   Pipe diameter:       137.16 cm      Operate sampler: Yes
   Default depth:         0.00 cm        Flow quantity:   40.000K l
Flow coefficient:       1.0000          Sampler mode: High flow
Default velocity:        0.00 m/s     Threshold depth:      12.50 cm


 Connection: Direct


─────── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────────
to move, ↵ to select, F10 for Help ════════════════════╛
Study name: moewws                          NUM Lock Thu Dec 13, 1990 18 41
```

```
───────────────────────── QBase ──────────────────────────
───────────────── Datalogger setup ──────────────────
    ID: 31                    Instrument:   PV Q-Logger depth, velocity
Comment: L102 40th street and lake promenade

   Probe: Type 2 (5 psi)     Depth: cm      Depth offset:        0.00 cm
Direction: Upstream           Velocity: m/s        Interval:  5 min
                                                    Memory: Slate

            Equation:   Point velocity (round pipe)
                Flow:  l/s

   Pipe diameter:        91.44 cm      Operate sampler: Yes
   Default depth:         0.00 cm        Flow quantity:    5.000K l
Flow coefficient:       1.0000          Sampler mode: High flow
Default velocity:        0.00 m/s     Threshold depth:       5.00 cm


 Connection: Direct


─────── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────────
to move, ↵ to select, F10 for Help ════════════════════╛
Study name: moewws                          NUM Lock Thu Dec 13, 1990 18:43
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 ─────────────────────────────── QBase ───────────────────────────
                       ────── Datalogger setup ──────
     ID: 33                         Instrument:   PV Q-Logger depth, velocity
 Comment: site #5 browns line mixed industrial and residential

     Probe: Type 2 (5 psi)      Depth: cm       Depth offset:        0.00 cm
 Direction: Upstream           Velocity: m/s         Interval: 5 min
                                                      Memory: Wraparound

            Equation:   Manning equation
                Flow: l/s

     Pipe diameter:          198.00 cm      Operate sampler: Yes
              Slope:          0.0050         Flow quantity:   50.000K l
 Manning Coefficient:         0.0130         Sampler mode: High flow
                                             Threshold depth:      7.50 cm



     Connection: Direct


 ──────── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────────
 to move, ⌡ to select, F10 for Help ─────────────────┘
 Study name: moewws                         NUM Lock Thu Dec 13, 1990 18:46
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```
 ─────────────────────────────── QBase ───────────────────────────
                       ────── Datalogger setup ──────
     ID:  7                         Instrument:   PV Q-Logger depth, velocity
 Comment: site #6 kingston road. south of highview ave. at hotel

     Probe: Type 2 (5 psi)      Depth: mm       Depth offset:        0.00 mm
 Direction: Upstream           Velocity: m/s         Interval:  5 min
                                                      Memory: Wraparound

            Equation:   Point velocity (round pipe)
                Flow: l/s

     Pipe diameter:          675.00 mm      Operate sampler: Yes
     Default depth:           0.00 mm        Flow quantity:    2.000K l
 Flow coefficient:            1.0000         Sampler mode: High flow
 Default velocity:            0.00 m/s       Threshold depth:     40.00 mm



     Connection: Direct


 ──────── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────────
 to move, ⌡ to select, F10 for Help ─────────────┘
 Study name: moewws                         NUM Lock Thu Dec 13, 1990 18 48
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┌─────────────────────────── QBase ───────────────────────────┐
│┌────────────────────── Datalogger setup ──────────────────────┐│
││    ID: 26                    Instrument:  PV Q-Logger depth, velocity│
││Comment: site #7 cecil cres.                                      │
││                                                                  │
││   Probe: Type 2 (5 psi)   Depth: cm     Depth offset:     0.00 cm│
││Direction: Upstream       Velocity: m/s      Interval:  5 min     │
││                                            Memory: Wraparound     │
││                                                                  │
││            Equation:  Manning equation                           │
││              Flow: l/s                                           │
││                                                                  │
││   Pipe diameter:      135.00 cm     Operate sampler: Yes         │
││           Slope:      0.0050         Flow quantity:   15.000K l  │
││Manning Coefficient:   0.0130         Sampler mode: High flow     │
││                                     Threshold depth:     4.00 cm │
││                                                                  │
││                                                                  │
││   Connection: Direct                                             │
││                                                                  │
││                                                                  │
│└──── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────┘│
│ to move, ⏎ to select, F10 for Help ══════════════            │
│ Study name: moewws                    NUM Lock Thu Dec 13, 1990 18:51│
└─────────────────────────────────────────────────────────────┘

┌─────────────────────────── QBase ───────────────────────────┐
│┌────────────────────── Datalogger setup ──────────────────────┐│
││    ID: 12                    Instrument:  PV Q-Logger depth, velocity│
││Comment: site #8 E11 greenwood race track                         │
││                                                                  │
││   Probe: Type 2 (5 psi)   Depth: cm     Depth offset:     0.00 cm│
││Direction: Downstream     Velocity: m/s      Interval:  5 min     │
││                                            Memory: Wraparound     │
││                                                                  │
││            Equation:  Point velocity (rectangular or trapezoidal)│
││              Flow: l/s                                           │
││                                                                  │
││   Channel Height:     182.00 cm     Operate sampler: Yes         │
││   Default depth:        0.00 cm      Flow quantity:   50.000K l  │
││Flow coefficient:      1.0000         Sampler mode: High flow     │
││Default velocity:        0.00 m/s    Threshold depth:     8.00 cm │
││  Width at bottom:     264.00 cm                                  │
││    Width at top:      264.00 cm                                  │
││                                                                  │
││   Connection: Direct                                             │
││                                                                  │
││                                                                  │
│└──── F1/F2-Change ID  F3-Duplicate  ENTER-View options ────┘│
│ to move, ⏎ to select, F10 for Help ══════════════            │
│ Study name: moewws                    NUM Lock Thu Dec 13, 1990 18:52│
└─────────────────────────────────────────────────────────────┘
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┌────────────────────────────── QBase ──────────────────────────────┐
│                          ── Datalogger setup ──                     │
│     ID: 14                    Instrument:  PV Q-Logger depth, velocity │
│ Comment: site #9 highland creek ditch installed in flume            │
│                                                                      │
│    Probe: Type 2 (5 psi)    Depth: ft     Depth offset:      0.00 ft │
│ Direction: Downstream      Velocity: fps       Interval:  5 min      │
│                                                Memory: Wraparound     │
│                                                                      │
│          Equation:  Simple weir or flume {A * depth⁻B}              │
│              Flow: l/s                                               │
│                                                                      │
│            A:    12.3000           Operate sampler: Yes              │
│     Max depth:     1.17 ft          Flow quantity:   247.000 l       │
│            B:     1.7200            Sampler mode: High flow          │
│                                    Threshold depth:     0.21 ft      │
│                                                                      │
│                                                                      │
│                                                                      │
│    Connection: Direct                                               │
│                                                                      │
│                                                                      │
│         ── F1/F2-Change ID  F3-Duplicate  ENTER-View options ──     │
│ to move, ⌐ to select, F10 for Help ════════════════════╛            │
│ Study name: moewws                       NUM Lock Thu Dec 13, 1990 18 53 │
└──────────────────────────────────────────────────────────────────┘
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┌────────────────────────────── QBase ──────────────────────────────┐
│                          ── Datalogger setup ──                     │
│     ID:  5                    Instrument:  PV Q-Logger depth, velocity │
│ Comment: site #10 kingston road at apt. bldg.                       │
│                                                                      │
│    Probe: Type 2 (5 psi)    Depth: mm     Depth offset:      0.00 mm │
│ Direction: Upstream        Velocity: m/s       Interval:  5 min      │
│                                                Memory: Wraparound     │
│                                                                      │
│          Equation:  Point velocity (round pipe)                     │
│              Flow: l/s                                               │
│                                                                      │
│    Pipe diameter:    900.00 mm      Operate sampler: Yes            │
│    Default depth:      0.00 mm       Flow quantity:   5.000K l       │
│ Flow coefficient:    1.0000          Sampler mode: High flow         │
│ Default velocity:      0.00 m/s     Threshold depth:    50.00 mm     │
│                                                                      │
│                                                                      │
│    Connection: Direct                                               │
│                                                                      │
│                                                                      │
│         ── F1/F2-Change ID  F3-Duplicate  ENTER-View options ──     │
│ to move, ⌐ to select, F10 for Help ════════════════════╛            │
│ Study name: moewws                       NUM Lock Thu Dec 13, 1990 18 54 │
└──────────────────────────────────────────────────────────────────┘
```

```
                                    QBase
                         Datalogger setup
     ID:  8                    Instrument:  PV Q-Logger depth, velocity
 Comment: site #11 brooklawn ave.

    Probe: Type 2 (5 psi)     Depth:  cm     Depth offset:        0.00 cm
 Direction: Upstream         Velocity:  m/s        Interval:  5 min
                                                     Memory:  Wraparound

            Equation:  Point velocity (round pipe)
               Flow:  l/s

    Pipe diameter:       137.16 cm     Operate sampler: Yes
    Default depth:         0.00 cm       Flow quantity:    15.000K l
 Flow coefficient:       1.0000          Sampler mode: High flow
 Default velocity:        0.00 m/s     Threshold depth:       8.00 cm



    Connection: Direct


            F1/F2-Change ID  F3-Duplicate  ENTER-View options
 to move, ⏎ to select, F10 for Help
 Study name: moewws                        NUM Lock Thu Dec 13, 1990 18:56
```

# APPENDIX 2

## TABLE A2.1

## PARAMETER RANGES FOR RUNOFF VOLUME ERROR ANALYSIS

| | | UNITS | HIGH ESTIMATE | VALUES USED | LOW ESTIMATE |
|---|---|---|---|---|---|
| AVERAGE IMPERVIOUS CHANGED BY | | PERCENT | 20 | | 15 |
| AREA CHANGED BY | | PERCENT | 5 | | 20 |
| INFILTRATION | INITIAL | mm/hr | 30 | 40 | 70 |
| | FINAL | mm/hr | 4 | 4 | 8 |
| | DECAY | 1/sec | 0.0013 | 0.00115 | 0.001 |
| DEPRESSION STORAGE | IMP. | mm | 1 | 1.5 | 2 |
| | PER. | mm | 2 | 4 | 5 |
| GROUND SLOPE | | PERCENT | 3 | 2 | 1 |
| % IMPERVIOUSNESS WITH ZERO DETENTION | | PERCENT | 75 | 50 | 25 |
| INFILTRATION RECOVERY | | 1/sec | 0.007 | 0.01 | 0.02 |
| EVAPORATION | | mm/day | 1 | 2 | 3 |
| ESTIMATED ERROR FROM PREDICTED VOLUMES | | PERCENT | 134 | | 53 |

## TABLE A2.2
## PREDICTED VOLUMES FROM MODELLING ERROR ANALYSIS
## HIGH AND LOW VOLUME RANGE FOR SUMMER/FALL SEASON (m^3)

| CATCHMENT | HIGH ESTIMATE | VALUE USED | LOW ESTIMATE |
|---|---|---|---|
| E5 | 1,240,000 | 879,000 | 517,000 |
| E10 | 530,000 | 374,000 | 219,000 |
| E8 | 445,000 | 317,000 | 187,000 |
| S18 | 447,000 | 311,000 | 181,000 |
| S6 | 388,890 | 268,200 | 154,215 |
| S10 | 366,000 | 252,000 | 145,000 |
| S12 | 261,000 | 181,000 | 105,000 |
| S7 | 239,000 | 165,000 | 95,200 |
| E4 | 230,000 | 160,300 | 93,100 |
| S9 | 233,000 | 160,000 | 91,900 |
| S4 | 214,890 | 148,200 | 85,215 |
| S8 | 199,000 | 137,000 | 78,800 |
| S11 | 181,000 | 126,000 | 73,700 |
| S2 | 175,450 | 121,000 | 69,575 |
| S13 | 156,000 | 106,000 | 60,100 |
| S16 | 149,000 | 100,000 | 56,200 |
| S17 | 138,000 | 98,700 | 57,800 |
| E11 | 127,000 | 88,400 | 51,100 |
| E9 | 110,000 | 75,600 | 43,100 |
| S14 | 107,000 | 75,300 | 43,900 |
| S15 | 107,000 | 71,800 | 40,000 |
| S5 | 102,805 | 70,900 | 40,768 |
| E7 | 97,200 | 67,300 | 38,700 |
| S1 | 85,840 | 59,200 | 34,040 |
| S3 | 73,950 | 51,000 | 29,325 |
| E12 | 41,200 | 30,000 | 12,900 |
| E1 | 42,300 | 28,600 | 15,800 |
| E3 | 38,200 | 26,000 | 14,700 |
| E2 | 24,700 | 17,300 | 9,890 |
| E6 | 19,800 | 13,500 | 7,580 |
| TOTAL | 6,570,225 | 4,579,300 | 2,651,608 |

Note: High and low values for catchments with CSO, S1 to S6, were estimated
from changes observed from other catchments

## TABLE A2.3
## SUMMARY OF RUNOFF VOLUMES FOR THE 7 LARGEST
## SUMMER/FALL RAINFALL EVENTS BY CATCHMENT

| CATCHMENT | RUNOFF VOLUME (m^3) | | | | | | |
| NAME | EVENT NUMBER | | | | | | TOTAL |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|---|
| E1 | 4,817 | 2,748 | 1,855 | 1,641 | 1,677 | 1,356 | 14,095 |
| E2 | 2,391 | 1,713 | 1,178 | 1,035 | 1,035 | 856 | 8,207 |
| E3 | 4,139 | 2,533 | 1,748 | 1,499 | 1,534 | 1,249 | 12,703 |
| E4 | 21,053 | 16,129 | 10,919 | 9,599 | 9,884 | 8,207 | 75,790 |
| E5 | 106,512 | 90,598 | 61,089 | 52,525 | 55,915 | 47,815 | 414,453 |
| E6 | 2,177 | 1,320 | 892 | 785 | 785 | 642 | 6,601 |
| E7 | 9,277 | 6,708 | 4,532 | 3,996 | 4,068 | 3,354 | 31,936 |
| E8 | 37,645 | 32,828 | 22,159 | 18,947 | 20,268 | 17,377 | 149,224 |
| E9 | 10,847 | 7,458 | 5,067 | 4,460 | 4,567 | 3,747 | 36,146 |
| E10 | 45,745 | 38,359 | 25,906 | 22,337 | 23,693 | 20,161 | 176,200 |
| E11 | 11,740 | 8,849 | 5,995 | 5,281 | 5,424 | 4,496 | 41,784 |
| E12 | 5,816 | 2,248 | 1,534 | 1,320 | 1,356 | 1,106 | 13,381 |
| S1 | 5,733 | 5,548 | 3,899 | 3,483 | 3,421 | 2,743 | 24,826 |
| S2 | 11,718 | 11,340 | 7,970 | 7,119 | 6,993 | 5,607 | 50,747 |
| S3 | 4,940 | 4,781 | 3,360 | 3,001 | 2,948 | 2,364 | 21,394 |
| S4 | 14,352 | 13,889 | 9,761 | 8,719 | 8,565 | 6,867 | 62,152 |
| S5 | 6,867 | 6,646 | 4,670 | 4,172 | 4,098 | 3,286 | 29,739 |
| S6 | 25,977 | 25,139 | 17,667 | 15,782 | 15,502 | 12,430 | 112,496 |
| S7 | 22,052 | 16,557 | 11,204 | 9,813 | 10,205 | 8,528 | 78,359 |
| S8 | 18,947 | 13,666 | 9,242 | 8,136 | 8,350 | 6,922 | 65,263 |
| S9 | 21,945 | 15,950 | 10,812 | 9,492 | 9,777 | 8,136 | 76,111 |
| S10 | 34,148 | 25,192 | 17,056 | 14,951 | 15,486 | 12,917 | 119,751 |
| S11 | 16,200 | 12,810 | 8,635 | 7,565 | 7,886 | 6,601 | 59,697 |
| S12 | 23,408 | 18,341 | 12,382 | 10,776 | 11,276 | 9,527 | 85,709 |
| S13 | 16,307 | 10,419 | 7,101 | 6,209 | 6,351 | 5,174 | 51,561 |
| S14 | 9,527 | 7,600 | 5,138 | 4,532 | 4,674 | 3,854 | 35,326 |
| S15 | 11,989 | 6,922 | 4,746 | 4,139 | 4,211 | 3,426 | 35,433 |
| S16 | 16,093 | 9,741 | 6,637 | 5,816 | 5,923 | 4,853 | 49,064 |
| S17 | 11,954 | 10,027 | 6,780 | 5,995 | 6,137 | 5,067 | 45,959 |
| S18 | 40,143 | 31,508 | 21,302 | 18,591 | 19,376 | 16,307 | 147,226 |
| **TOTAL** | 574,459 | 457,566 | 311,234 | 271,714 | 281,385 | 234,974 | 2,131,333 |

**NOTES:**
All volumes estimated from continuous event simulation modelling for
the typical year of rainfall, except for the combined sewer catchments
S1 to S6 which were prorated based on annual estimates and event rainfall.

SUMMARY OUTPUT FROM LOADS V2.6 Sept. 1990

Run   1: Concentration file: chem1.wet                         Discharge file: wetvol.new
Mean flow (QBAR): 205000000. L/d   Std: 230000000.  Skew:  1.75  Kurt:  6.32  Flow points:  90  (LogStd or TStd:   1.494)

Statistical Analysis of Detected Concentrations

| Parameter Code | N | ND | Units | Raw data statistics | | | | Range | | Log(e) Transform Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Std | Skew | Kurt | Min | Max | Mean | Std | Skew | Kurt |
| ALKT | 58 | 58 | mg/L | 97.366 | 58.553 | 1.494 | 5.588 | 27.300 | 303.000 | 4.423 | 0.559 | 0.173 | 2.741 |
| BOD5 | 2 | 2 | mg/L | 418.500 | 0.000 | 0.000 | 0.000 | 172.000 | 665.000 | 5.824 | 0.000 | 0.000 | 0.000 |
| CCNAUR | 57 | 15 | mg/L | 0.029 | 0.032 | 2.114 | 8.167 | 0.010 | 0.120 | -3.923 | 0.856 | 0.906 | 3.408 |
| CCNFUR | 57 | 0 | mg/L | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CLIDUR | 1 | 1 | mg/L | 5.200 | 0.000 | 0.000 | 0.000 | 5.200 | 5.200 | 1.649 | 0.000 | 0.000 | 0.000 |
| COD | 56 | 56 | mg/L | 706.929 | 977.241 | 4.031 | 24.329 | 18.000 | 6416.000 | 5.972 | 1.124 | -0.190 | 3.497 |
| DOC | 2 | 1 | mg/L | 332.500 | 0.000 | 0.000 | 0.000 | 332.500 | 332.500 | 5.807 | 0.000 | 0.000 | 0.000 |

SUMMARY OUTPUT FROM LOADS V2.6 Sept. 1990

Run   1: Concentration file: chem2.wet                         Discharge file: wetvol.new
Mean flow (QBAR): 205000000. L/d   Std: 230000000.  Skew:  1.75  Kurt:  6.32  Flow points:  90  (LogStd or TStd:   1.494)

Statistical Analysis of Detected Concentrations

| Parameter Code | N | ND | Units | Raw data statistics | | | | Range | | Log(e) Transform Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Std | Skew | Kurt | Min | Max | Mean | Std | Skew | Kurt |
| HARDT | 5 | 5 | mg/L | 185.400 | 155.343 | 1.054 | 9.014 | 45.000 | 429.000 | 4.892 | 0.955 | -0.115 | 5.886 |
| PHNOL | 56 | 56 | ug/L | 21.707 | 34.188 | 6.385 | 47.902 | 2.400 | 260.000 | 2.713 | 0.759 | 0.538 | 6.216 |
| RSF | 1 | 1 | mg/L | 52.000 | 0.000 | 0.000 | 0.000 | 52.000 | 52.000 | 3.951 | 0.000 | 0.000 | 0.000 |
| RSP | 56 | 56 | mg/L | 118.146 | 113.322 | 2.169 | 9.616 | 3.400 | 625.000 | 4.331 | 1.054 | -0.787 | 4.312 |
| RST | 56 | 56 | mg/L | 460.148 | 343.837 | 2.013 | 8.335 | 64.000 | 1900.000 | 5.902 | 0.689 | -0.089 | 3.447 |
| SOLEXT | 51 | 46 | mg/L | 9.761 | 9.608 | 3.406 | 19.382 | 1.000 | 60.000 | 1.950 | 0.819 | -0.016 | 3.334 |
| SSIDUR | 3 | 1 | ug/L | 4.000 | 0.000 | 0.000 | 0.000 | 4.000 | 4.000 | 1.386 | 0.000 | 0.000 | 0.000 |

SUMMARY OUTPUT FROM LOADS V2.6 Sept. 1990

Run   1: Concentration file: org1.wet                          Discharge file: wetvol.new
Mean flow (QBAR): 205000000. L/d   Std: 230000000.  Skew:  1.75  Kurt:  6.32  Flow points:  90  (LogStd or TStd:   1.494)

Statistical Analysis of Detected Concentrations

| Parameter Code | N | ND | Units | Raw data statistics | | | | Range | | Log(e) Transform Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Std | Skew | Kurt | Min | Max | Mean | Std | Skew | Kurt |
| P1PCBT | 54 | 5 | ng/L | 2501.400 | 4252.714 | 2.087 | 12.402 | 37.000 | 10000.000 | 6.351 | 2.122 | 0.158 | 7.754 |
| X2HCB | 54 | 28 | ng/L | 0.461 | 0.379 | 0.812 | 2.859 | 0.100 | 1.340 | -1.153 | 0.924 | 0.030 | 1.753 |
| P1HEPT | 54 | 7 | ng/L | 0.499 | 0.264 | 1.082 | 7.220 | 0.190 | 1.000 | -0.817 | 0.542 | -0.200 | 5.521 |
| P1ALDR | 54 | 13 | ng/L | 3.557 | 2.394 | 0.235 | 3.032 | 0.180 | 7.550 | 0.887 | 1.121 | -1.348 | 5.169 |
| P1PPDE | 54 | 25 | ng/L | 0.406 | 0.467 | 3.548 | 17.995 | 0.100 | 2.400 | -1.239 | 0.767 | 0.762 | 4.426 |
| P1MIRX | 54 | 1 | ng/L | 0.340 | 0.000 | 0.000 | 0.000 | 0.340 | 0.340 | -1.079 | 0.000 | 0.000 | 0.000 |
| P1BHCA | 54 | 53 | ng/L | 1.846 | 0.926 | 0.840 | 4.732 | 0.230 | 5.000 | 0.468 | 0.590 | -0.985 | 4.608 |
| P1BHCG | 54 | 52 | ng/L | 1.458 | 1.364 | 1.988 | 7.324 | 0.100 | 6.580 | 0.024 | 0.856 | -0.009 | 3.262 |
| P1BHCB | 54 | 1 | ng/L | 1.400 | 0.000 | 0.000 | 0.000 | 1.400 | 1.400 | 0.336 | 0.000 | 0.000 | 0.000 |
| P1CHLA | 54 | 24 | ng/L | 0.666 | 0.531 | 1.470 | 4.955 | 0.200 | 2.000 | -0.667 | 0.717 | 0.493 | 2.523 |

SUMMARY OUTPUT FROM LOADS V2.6 Sept. 1990

Run   1: Concentration file: bact1.wet                         Discharge file: wetvol.new
Mean flow (QBAR): 205000000. L/d   Std: 230000000.  Skew:  1.75  Kurt:  6.32  Flow points:  90  (LogStd or TStd:   1.494)

Statistical Analysis of Detected Concentrations

| Parameter Code | N | ND | Units | Raw data statistics | | | | Range | | Log(e) Transform Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Std | Skew | Kurt | Min | Max | Mean | Std | Skew | Kurt |
| ECMF | 41 | 40 | CH | 359154. | 1100631. | 3.966 | 20.015 | 10.0 | 5800000. | 8.937 | 3.179 | 0.181 | 3.007 |
| FCMF | 40 | 39 | CH | 527784. | 1558971. | 3.511 | 15.770 | 30.0 | 7600000. | 9.260 | 3.187 | 0.253 | 2.918 |
| FSMF | 41 | 40 | CH | 64774. | 150433. | 2.841 | 10.448 | 20.0 | 610000. | 8.861 | 2.481 | -0.426 | 3.704 |
| PSAMF | 41 | 37 | CH | 3817. | 12927. | 4.087 | 10.297 | 3.0 | 62000. | 5.821 | 1.44 | 80 | 1.89 |

## TABLE A2.5

## Summmary of Regressions for EMC Versus Event Volume

| Outfall | Parameter | # | r^2 | Slope | T-test |
|---------|-----------|---|-----|-------|--------|
| Brooklawn | Alkalinity (as CaCO3) | 5 | 0.26399 | -0.117 | -1.198 |
| Brooklawn | Cyanide - Avl. Unfil. React. | 5 | 0.12562 | -0.139 | -0.758 |
| Brooklawn | Chemical Oxygen Demand | 5 | 0.54138 | -0.256 | -2.173 |
| Brooklawn | Phenolics (4AAP) | 5 | 0.08519 | -0.049 | -0.610 |
| Brooklawn | Total suspended solids | 5 | 0.28465 | -0.146 | -1.262 |
| Brooklawn | Total solids | 5 | 0.38600 | -0.135 | -1.586 |
| Brooklawn | Solvent extractable (organic) | 5 | 0.42871 | -0.290 | -1.733 |
| Brooklawn | Nitrates | 5 | 0.02562 | -0.072 | -0.324 |
| Brooklawn | Nitrite | 5 | 0.48548 | -0.224 | -1.943 |
| Brooklawn | Total Kjeldahl Nitrogen | 5 | 0.45165 | -0.194 | -1.815 |
| Brooklawn | Total Phosphorous | 5 | 0.20177 | -0.203 | -1.006 |
| Brooklawn | E-Coli | 4 | 0.15416 | -0.247 | -0.739 |
| Brooklawn | Fecal Coliform MF | 4 | 0.14490 | -0.234 | -0.713 |
| Brooklawn | Fecal Streptroccus MF | 4 | 0.01978 | -0.055 | -0.246 |
| Brooklawn | Pseudomonas Aeruginosa MF | 4 | 0.43519 | -0.294 | -1.520 |
| Brooklawn | Silver | 5 | 0.00142 | 0.007 | 0.075 |
| Brooklawn | Aluminum | 5 | 0.11235 | -0.115 | -0.712 |
| Brooklawn | Barium | 5 | 0.01936 | 0.030 | 0.281 |
| Brooklawn | Cadmium | 5 | 0.39612 | 0.344 | 1.620 |
| Brooklawn | Chromium | 5 | 0.75084 | -0.289 | -3.472 |
| Brooklawn | Copper | 5 | 0.19094 | -0.144 | -0.972 |
| Brooklawn | Iron | 5 | 0.28594 | -0.127 | -1.266 |
| Brooklawn | Mercury | 5 | 0.10682 | 0.097 | 0.692 |
| Brooklawn | Manganese | 5 | 0.30206 | -0.139 | -1.316 |
| Brooklawn | Nickel | 5 | 0.74222 | -0.266 | -3.394 |
| Brooklawn | Lead | 5 | 0.05232 | -0.101 | -0.470 |
| Brooklawn | Zinc | 5 | 0.12923 | -0.069 | -0.770 |
| Brooklawn | Hexachlorobenzene | 4 | 0.31475 | 0.150 | 1.174 |
| Brooklawn | Heptachlor | 4 | 0.47836 | 0.337 | 1.659 |
| Brooklawn | Aldrin | 4 | 0.70830 | 0.367 | 2.699 |
| Brooklawn | PP DDE | 4 | 0.46826 | 0.186 | 1.625 |
| Brooklawn | Alpha-BHC (Hexachlorocyclohex) | 4 | 0.93182 | 0.165 | 6.403 |
| Brooklawn | Gamma-BHC (Lindane) | 4 | 0.80413 | 0.258 | 3.509 |
| Brooklawn | Alpha Chlordane | 4 | 0.10420 | 0.114 | 0.591 |
| Brooklawn | Gamma Chlordane | 4 | 0.11962 | 0.084 | 0.638 |
| Brooklawn | PP DDT | 4 | 0.22190 | 0.122 | 0.925 |
| Brooklawn | PP DDD | 4 | 0.15595 | 0.183 | 0.745 |
| Brooklawn | Heptachloroepoxide | 4 | 0.41099 | 0.149 | 1.447 |
| Brooklawn | Thiodan II | 4 | 0.11176 | 0.111 | 0.614 |
| Brooklawn | Thiodan Sulphate | 4 | 0.11176 | 0.096 | 0.614 |
| Brooklawn | Dieldrin | 4 | 0.46883 | 0.339 | 1.627 |
| Brooklawn | Endrin | 4 | 0.51621 | -0.349 | -1.789 |
| Brooklawn | DMDT-Methoxychlor | 4 | 0.39114 | -0.147 | -1.388 |
| Brooklawn | Hexachloroethane | 4 | 0.15595 | -0.177 | -0.745 |
| Brooklawn | Trichlorobenzene 1-3-5 | 4 | 0.13693 | 0.166 | 0.690 |
| Brooklawn | Trichlorobenzene 1-2-4 | 4 | 0.12475 | 0.157 | 0.654 |
| Brooklawn | Trichlorobenzene 1-2-3 | 4 | 0.37621 | 0.299 | 1.345 |
| Brooklawn | Hexachlorobutadiene | 4 | 0.35254 | -0.180 | -1.278 |
| Brooklawn | Trichlorotoluene 2-4-5 | 4 | 0.07169 | -0.141 | -0.481 |
| Brooklawn | Tetrachlorobenzene 1-2-4-5 | 4 | 0.99393 | 0.417 | 22.169 |
| Brooklawn | Tetrachlorobenzene 1-2-3-5 | 4 | 0.02510 | 0.084 | 0.278 |
| Brooklawn | Trichlorotoluene 2-6-A | 4 | 0.11133 | 0.132 | 0.613 |
| Brooklawn | Tetrachlorobenzene 1-2-3-4 | 4 | 0.30463 | -0.283 | -1.146 |
| Brooklawn | Pentachlorobenzene | 4 | 0.27601 | 0.201 | 1.069 |

# TABLE A2.6

## Summmmary of Regressions for EMC Versus Event Volume

| Outfall | Parameter | # | r^2 | Slope | T-test |
|---------|-----------|---|------|-------|--------|
| Cecil | Alkalinity (as CaCO3) | 6 | 0.07628 | -0.057 | -0.643 |
| Cecil | Cyanide - Avl. Unfil. React. | 6 | 0.22829 | -0.381 | -1.216 |
| Cecil | Chemical Oxygen Demand | 6 | 0.04139 | -0.107 | -0.465 |
| Cecil | Phenolics (4AAP) | 6 | 0.94055 | 0.712 | 8.894 |
| Cecil | Total suspended solids | 6 | 0.02014 | -0.070 | -0.321 |
| Cecil | Total solids | 6 | 0.16055 | -0.204 | -0.978 |
| Cecil | Solvent extractable (organic) | 6 | 0.00705 | -0.043 | -0.188 |
| Cecil | Nitrates | 7 | 0.02844 | -0.138 | -0.419 |
| Cecil | Nitrite | 6 | 0.11380 | -0.315 | -0.801 |
| Cecil | Total Kjeldahl Nitrogen | 7 | 0.05089 | -0.165 | -0.567 |
| Cecil | Total Phosphorous | 7 | 0.01879 | -0.075 | -0.339 |
| Cecil | E-Coli | 5 | 0.11669 | -0.525 | -0.727 |
| Cecil | Fecal Coliform MF | 5 | 0.08150 | -0.310 | -0.596 |
| Cecil | Fecal Streptroccus MF | 5 | 0.26278 | -0.497 | -1.194 |
| Cecil | Pseudomonas Aeruginosa MF | 5 | 0.02497 | -0.232 | -0.320 |
| Cecil | Silver | 8 | 0.07324 | -0.166 | -0.744 |
| Cecil | Aluminum | 8 | 0.00010 | 0.006 | 0.027 |
| Cecil | Barium | 8 | 0.00024 | 0.013 | 0.041 |
| Cecil | Cadmium | 8 | 0.73397 | 1.139 | 4.395 |
| Cecil | Chromium | 8 | 0.04993 | 0.131 | 0.607 |
| Cecil | Copper | 8 | 0.03912 | 0.214 | 0.534 |
| Cecil | Iron | 8 | 0.03538 | 0.133 | 0.507 |
| Cecil | Mercury | 8 | 0.05742 | -0.130 | -0.653 |
| Cecil | Manganese | 8 | 0.00643 | 0.070 | 0.213 |
| Cecil | Nickel | 8 | 0.02901 | 0.104 | 0.457 |
| Cecil | Lead | 8 | 0.00425 | 0.039 | 0.173 |
| Cecil | Zinc | 8 | 0.00167 | 0.022 | 0.108 |
| Cecil | Hexachlorobenzene | 6 | 0.00654 | 0.062 | 0.181 |
| Cecil | PP DDE | 6 | 0.09959 | 0.181 | 0.744 |
| Cecil | Alpha-BHC (Hexachlorocyclohex) | 6 | 0.21070 | -0.275 | -1.155 |
| Cecil | Gamma-BHC (Lindane) | 6 | 0.11970 | 0.177 | 0.825 |
| Cecil | Alpha Chlordane | 6 | 0.35678 | 0.573 | 1.665 |
| Cecil | Gamma Chlordane | 6 | 0.35424 | 0.489 | 1.656 |
| Cecil | OP DDT | 6 | 0.00000 | 0.000 | -1.020 |
| Cecil | PP DDT | 6 | 0.18625 | 0.248 | 1.070 |
| Cecil | Thiodan I | 6 | 0.00834 | -0.086 | -0.205 |
| Cecil | Dieldrin | 6 | 0.16698 | 0.287 | 1.001 |
| Cecil | Endrin | 6 | 0.24288 | -0.094 | -1.266 |
| Cecil | Hexachloroethane | 6 | 0.12150 | 0.125 | 0.832 |
| Cecil | Trichlorobenzene 1-3-5 | 6 | 0.05863 | -0.255 | -0.558 |
| Cecil | Trichlorobenzene 1-2-4 | 6 | 0.05413 | 0.188 | 0.535 |
| Cecil | Trichlorobenzene 1-2-3 | 6 | 0.05757 | 0.216 | 0.553 |
| Cecil | Hexachlorobutadiene | 6 | 0.04690 | -0.136 | -0.496 |
| Cecil | Trichlorotoluene 2-4-5 | 6 | 0.00461 | -0.059 | -0.152 |
| Cecil | Trichlorotoluene 2-3-6 | 6 | 0.01080 | 0.095 | 0.234 |
| Cecil | Tetrachlorobenzene 1-2-4-5 | 6 | 0.02904 | 0.109 | 0.387 |
| Cecil | Tetrachlorobenzene 1-2-3-5 | 6 | 0.00905 | 0.060 | 0.214 |
| Cecil | Trichlorotoluene 2-6-A | 6 | 0.19551 | 0.311 | 1.102 |
| Cecil | Tetrachlorobenzene 1-2-3-4 | 6 | 0.00003 | 0.004 | 0.012 |
| Cecil | Pentachlorobenzene | 6 | 0.06233 | 0.120 | 0.577 |

TABLE A2.7    Summary of Computed T-Values for determining differences in
the Event Mean Concentrations (EMC) by Land use

| Parameter | N | ND | Mean | Std | Log transformed Mean | Std | N | ND | Mean | Std | Log Transformed Mean | Std | DF | POOLED ST | Comp-t | DF | POOLED ST | Comp-t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | 13 | 13 | 110 | 42.125 | 4.634 | 0.369 | 15 | 15 | 112 | 51.276 | 4.619 | 0.438 | 33 | 0.441 | 3.841 | 35 | 0.463 | 3.719 |
| Biochemical Oxygen Demand (5 day) | 1 | 1 | 172 | | | | | | | | | | | | | | | |
| Cyanide - Avl. Unfil. React. | 15 | 2 | 0.002 | | | | 14 | 5 | 27764.78 | 2.1E+08 | 1.32 | 4.222 | | | | 33 | 2.750 | 1.391 |
| Cyanide - Free Unfil. React. | | | | | | | | | | | | | | | | | | |
| Chlorine | | | | | | | | | | | | | | | | | | |
| Chemical Oxygen Demand | 13 | 13 | 837 | 837.178 | 6.383 | 0.833 | 14 | 14 | 857 | 2003.2 | 5.82 | 1.366 | 32 | 1.101 | 1.303 | 33 | 1.301 | -0.127 |
| Dissolved Organic Carbon | | | | | | | | | | | | | | | | | | |
| Hardness | 2 | 2 | 318 | | | | | | | | | | | | | | | |
| Phenolics (4AAP) | 14 | 14 | 14.3 | 14.169 | 2.323 | 0.825 | 13 | 13 | 19.2 | 8.137 | 2.87 | 0.407 | 33 | 0.663 | -1.828 | 32 | 0.471 | 0.775 |
| Total dissolved solids | | | | | | | | | | | | | | | | | | |
| Total suspended solids | 13 | 13 | 172 | 525.213 | 3.984 | 1.527 | 14 | 14 | 115 | 101.868 | 4.451 | 0.763 | 32 | 1.159 | -0.484 | 33 | 0.794 | 0.981 |
| Total solids | 13 | 13 | 468 | 233.356 | 6.038 | 0.471 | 14 | 14 | 538 | 341.487 | 6.118 | 0.582 | 32 | 0.640 | 2.461 | 33 | 0.674 | 2.736 |
| Solvent extractable (organic) | 10 | 7 | 9.68 | 27.097 | 1.181 | 1.476 | 13 | 13 | 9.95 | 9.65 | 1.967 | 0.814 | 29 | 1.137 | -1.174 | 32 | 0.872 | 0.887 |
| Sulphide | 2 | 1 | 2 | | | | | | | | | | | | | | | |
| Ammonium | 18 | 14 | 0.002 | 0.003 | -6.51 | 1.019 | 17 | 9 | 0.003 | 0.01 | -7.25 | 1.641 | 40 | 1.362 | 1.118 | 39 | 1.612 | -0.519 |
| Silver | 18 | 18 | 1.57 | 2.234 | -0.102 | 1.052 | 17 | 17 | 1.49 | 1.264 | 0.128 | 0.736 | 40 | 1.060 | 0.284 | 39 | 0.937 | 1.091 |
| Aluminum | 18 | 2 | 0.002 | | | | 17 | 2 | 0.001 | | | | | | | | | |
| Arsenic | 18 | 18 | 0.051 | 0.031 | -3.134 | 0.564 | 17 | 17 | 0.057 | 0.039 | -3.055 | 0.62 | 40 | 0.729 | 3.716 | 39 | 0.753 | 3.873 |
| Barium | | | | | | | | | | | | | | | | | | |
| Beryllium | 18 | 12 | 0.018 | 0.394 | -7.118 | 2.488 | 17 | 8 | 0.001 | 0.002 | -8.387 | 1.543 | 40 | 2.275 | 2.594 | 39 | 1.867 | 0.965 |
| Cadmium | 18 | 16 | 0.027 | 0.08 | -4.726 | 1.502 | 17 | 14 | 0.011 | 0.019 | -5.196 | 1.175 | 40 | 1.406 | 1.911 | 39 | 1.260 | 0.921 |
| Chromium | 18 | 17 | 0.91 | 17.352 | -3.04 | 2.428 | 17 | 17 | 0.064 | 0.112 | -3.449 | 1.184 | 40 | 1.831 | 2.004 | 39 | 1.153 | 2.011 |
| Copper | 18 | 17 | 5.47 | 20.595 | 0.341 | 1.649 | 17 | 17 | 4.87 | 5.993 | 1.12 | 0.961 | 40 | 1.323 | -0.737 | 39 | 0.970 | 1.544 |
| Iron | 18 | 13 | 0.039 | 0.054 | -3.769 | 1.027 | 17 | 17 | 0.081 | 0.062 | -2.737 | 0.675 | 40 | 0.889 | -1.908 | 39 | 0.723 | 2.194 |
| Mercury | 18 | 18 | 0.13 | 0.109 | -2.273 | 0.718 | 17 | 17 | 0.3 | 0.386 | -1.703 | 0.993 | 40 | 0.779 | 0.671 | 39 | 0.903 | 2.562 |
| Manganese | 18 | 18 | 0.015 | 0.017 | -4.594 | 0.909 | 17 | 15 | 0.01 | 0.011 | -5.067 | 0.916 | 40 | 0.930 | 2.558 | 39 | 0.934 | 0.909 |
| Nickel | 18 | 18 | 0.048 | 0.044 | -3.342 | 0.785 | 17 | 17 | 0.063 | 0.053 | -3.025 | 0.73 | 40 | 0.798 | 1.065 | 39 | 0.775 | 2.368 |
| Lead | 18 | 3 | 0.001 | | | | 17 | 3 | 0.001 | | | | | | | | | |
| Selenium | 18 | 18 | 0.32 | 0.834 | -2.175 | 1.436 | 17 | 17 | 0.17 | 0.123 | -1.998 | 0.656 | 40 | 1.052 | 0.238 | 39 | 0.609 | 1.321 |
| Zinc | 15 | 7 | 0.19 | 0.763 | -3.034 | 1.672 | 16 | 1 | 0.048 | | | | 37 | 1.065 | -8.659 | | | |
| Nitrates | 15 | 13 | 10.1 | 108.137 | -0.068 | 2.181 | 16 | 11 | 0.53 | 1.696 | -1.834 | 1.552 | 37 | 2.392 | 1.980 | 38 | 2.170 | -0.296 |
| Nitrite | 13 | 11 | 0.047 | 0.08 | -3.726 | 1.161 | 14 | 10 | 0.055 | 0.233 | -4.386 | 1.72 | 32 | 1.371 | 1.232 | 33 | 1.596 | -0.116 |
| Total Keljehl Nitrogen | 15 | 15 | 2.93 | 3.89 | 0.566 | 1.008 | 16 | 16 | 2.54 | 1.63 | 0.762 | 0.587 | 37 | 0.927 | 0.157 | 38 | 0.762 | 0.992 |
| Total Phosphorous | 15 | 15 | 0.65 | 1.724 | -1.467 | 1.442 | 16 | 16 | 0.55 | 0.538 | -0.944 | 0.823 | 37 | 1.136 | -0.669 | 38 | 0.849 | 0.996 |
| E-Coli | 10 | 10 | 38800 | 2867200 | 6.264 | 2.933 | 10 | 10 | 445000 | 5985320 | 10.403 | 2.281 | 23 | 2.697 | -2.705 | 23 | 2.407 | 1.181 |
| Fecal Coliform MF | 10 | 10 | 38300 | 1872842 | 6.663 | 2.789 | 10 | 10 | 543000 | 5654316 | 10.856 | 2.167 | 22 | 2.729 | -2.510 | 22 | 2.459 | 1.333 |
| Fecal Streptroccus MF | 10 | 9 | 320226 | 1.9E+08 | 6.304 | 3.57 | 10 | 10 | 45200 | 78912 | 10.021 | 1.182 | 23 | 2.612 | -2.556 | 23 | 1.375 | 1.766 |
| Pseudomonas Aeruginosa MF | 10 | 7 | 5569 | 1149109 | 3.295 | 3.265 | 10 | 10 | 1830 | 4591 | 6.519 | 1.41 | 23 | 2.209 | -2.130 | 23 | 1.053 | 3.031 |

TABLE A2.8    Summary of Computed T-Values for determining differences in
the Event Mean Concentrations (EMC) by Land use

| Parameter | Commercial Stations (#6) | | | | Log transformed | | Residential Stations (#4, 10 #11) | | | | Log Transformed | | Comparison | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | ND | Mean | Std | Mean | Std | N | ND | Mean | Std | Mean | Std | DF | POOLED ST | Comp-t |
| Alkalinity (as CaCO3) | 6 | 6 | 103 | 65.178 | 4.462 | 0.582 | 22 | 22 | 63.3 | 30.66 | 4.042 | 0.459 | 26 | 0.506 | 1.801 |
| Biochemical Oxygen Demand (5 day) | | | | | | | | | | | | | | | |
| Cyanide - Avl. Unfil. React. | 5 | 1 | 0.002 | | | | 21 | 5 | 0.007 | | | | | | |
| Cyanide - Free Unfil. React. | | | | | | | | | | | | | | | |
| Chlorine | | | | | | | | | | | | | | | |
| Chemical Oxygen Demand | 6 | 6 | 601 | 663.795 | 6 | 0.893 | 21 | 21 | 724 | 1278.422 | 5.877 | 1.19 | 25 | 1.175 | 0.226 |
| Dissolved Organic Carbon | | | | | | | | | | | | | | | |
| Hardness | | | | | | | 3 | 3 | 106 | 98.296 | 4.357 | 0.786 | | | |
| Phenolics (4AAP) | 6 | 6 | 17.2 | 17.402 | 2.491 | 0.84 | 21 | 21 | 17.4 | 9.013 | 2.741 | 0.486 | 25 | 0.606 | -0.891 |
| Total dissolved solids | | | | | | | | | | | | | | | |
| Total suspended solids | 6 | 6 | 220 | 269.174 | 4.94 | 0.955 | 21 | 21 | 88.6 | 80.594 | 4.182 | 0.777 | 25 | 0.852 | 1.922 |
| Total solids | 6 | 6 | 722 | 555.618 | 6.35 | 0.682 | 21 | 21 | 307 | 243.321 | 5.482 | 0.698 | 25 | 0.722 | 2.598 |
| Solvent extractable (organic) | 5 | 4 | 7.08 | 13.222 | 1.208 | 1.225 | 21 | 20 | 7.91 | 8.336 | 1.694 | 0.865 | 24 | 0.984 | -0.993 |
| Sulphide | | | | | | | | | | | | | | | |
| Ammonium | 6 | 4 | 0.005 | 0.016 | -6.524 | 1.556 | 24 | 15 | 0.003 | 0.009 | -6.985 | 1.521 | 28 | 1.582 | 0.639 |
| Silver | 6 | 6 | 6.65 | 22.585 | 0.629 | 1.59 | 24 | 24 | 1.38 | 1.875 | -0.196 | 1.021 | 28 | 1.198 | 1.509 |
| Aluminum | 6 | 1 | 0.001 | | | | 24 | 4 | 0.001 | | | | | | |
| Arsenic | 6 | 6 | 0.074 | 0.035 | -2.706 | 0.452 | 24 | 24 | 0.026 | 0.025 | -3.979 | 0.805 | 28 | 0.774 | 3.603 |
| Barium | | | | | | | | | | | | | | | |
| Beryllium | 6 | 4 | 0.001 | 0.001 | -7.652 | 1.094 | 24 | 9 | 0.001 | 0.007 | -8.958 | 1.995 | 28 | 1.915 | 1.494 |
| Cadmium | 6 | 6 | 0.011 | 0.006 | -4.643 | 0.509 | 24 | 20 | 0.009 | 0.017 | -5.564 | 1.266 | 28 | 1.196 | 1.688 |
| Chromium | 6 | 5 | 0.076 | 0.115 | -3.172 | 1.091 | 24 | 24 | 0.027 | 0.041 | -4.184 | 1.08 | 28 | 1.120 | 1.979 |
| Copper | 6 | 6 | 12.6 | 42.427 | 1.28 | 1.584 | 24 | 24 | 2.95 | 3.494 | 0.645 | 0.936 | 28 | 1.135 | 1.226 |
| Iron | 6 | 5 | 0.088 | 0.143 | -3.083 | 1.139 | 24 | 23 | 0.051 | 0.042 | -3.24 | 0.726 | 28 | 0.854 | 0.403 |
| Mercury | 6 | 6 | 0.25 | 0.309 | -1.831 | 0.955 | 24 | 24 | 0.12 | 0.112 | -2.436 | 0.791 | 28 | 0.855 | 1.550 |
| Manganese | 6 | 6 | 0.028 | 0.048 | -4.265 | 1.175 | 24 | 21 | 0.007 | 0.008 | -5.336 | 0.907 | 28 | 1.000 | 2.345 |
| Nickel | 6 | 6 | 0.084 | 0.076 | -2.778 | 0.776 | 24 | 23 | 0.037 | 0.033 | -3.607 | 0.774 | 28 | 0.802 | 2.266 |
| Lead | 6 | 1 | 0.001 | | | | 24 | 1 | 0.001 | | | | | | |
| Selenium | 6 | 6 | 0.3 | 0.605 | -2.028 | 1.279 | 24 | 24 | 0.12 | 0.072 | -2.253 | 0.546 | 28 | 0.779 | 0.633 |
| Zinc | 6 | 3 | 0.088 | 0.062 | -2.63 | 0.634 | 24 | 4 | 0.48 | | | | 28 | 0.293 | -19.633 |
| Nitrates | 6 | 6 | 0.99 | 0.907 | -0.318 | 0.782 | 24 | 18 | 3.66 | 68.229 | -1.627 | 2.419 | 28 | 2.269 | 1.264 |
| Nitrite | 6 | 6 | 0.11 | 0.137 | -2.73 | 0.99 | 21 | 16 | 0.037 | 0.094 | -4.322 | 1.425 | 25 | 1.393 | 2.469 |
| Total Keljehl Nitrogen | 6 | 6 | 1.79 | 1.68 | 0.27 | 0.793 | 24 | 24 | 2.37 | 2.362 | 0.518 | 0.831 | 28 | 0.852 | -0.637 |
| Total Phosphorous | 6 | 5 | 0.5 | 1.22 | -1.673 | 1.396 | 24 | 24 | 0.42 | 0.417 | -1.217 | 0.831 | 28 | 1.005 | -0.994 |
| E-Coli | 4 | 3 | 18194 | 715796 | 6.136 | 2.71 | 15 | 15 | 155000 | 2311528 | 9.242 | 2.327 | 17 | 2.551 | -2.164 |
| Fecal Coliform MF | 4 | 3 | 21932 | 940838 | 6.237 | 2.742 | 14 | 14 | 289000 | 6259590 | 9.499 | 2.48 | 16 | 2.695 | -2.135 |
| Fecal Streptroccus MF | 4 | 4 | 52889 | 1427774 | 7.58 | 2.568 | 15 | 15 | 22300 | 55301 | 9.03 | 1.402 | 17 | 1.813 | -1.421 |
| Pseudomonas Aeruginosa MF | 4 | 3 | 34917 | 26427866 | 3.832 | 3.641 | 15 | 15 | 222 | 150 | 5.216 | 0.612 | 17 | 1.857 | -1.324 |

**APPENDIX 3**

TABLE A3.1 Estimated Event Mean Concentration for water quality parameters by Land use

| Parameter | N | ND | Units | Commercial Stations (#6) Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | 6 | 6 | mg/L | 103.000 | 78.500 | 135.000 |
| Biochemical Oxygen Demand (5 day) | | | mg/L | NC | | |
| Cyanide - Avl. Unfil. React. | 5 | 1 | mg/L | 0.002# | | |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | | | mg/L | NC | | |
| Chemical Oxygen Demand | 6 | 6 | mg/L | 601.000 | 317.000 | 1140.000 |
| Dissolved Organic Carbon | | | mg/L | NC | | |
| Hardness | | | mg/L | NC | | |
| Phenolics (4AAP) | 6 | 6 | ug/L | 17.200 | 9.780 | 30.300 |
| Total dissolved solids | | | mg/L | NC | | |
| Total suspended solids | 6 | 6 | mg/L | 220.000 | 106.000 | 457.000 |
| Total solids | 6 | 6 | mg/L | 722.000 | 498.000 | 1050.000 |
| Solvent extractable (organic) | 5 | 4 | mg/L | 7.080 | 1.900 | 26.400 |
| Sulphide | | | ug/L | NC | | |
| Ammonium | 6 | 3 | mg/L | 0.088 | 0.064 | 0.120 |
| Nitrates | 6 | 6 | mg/L | 0.990 | 0.610 | 1.610 |
| Nitrite | 6 | 6 | mg/L | 0.110 | 0.050 | 0.240 |
| Total Keljehl Nitrogen | 6 | 6 | mg/L | 1.790 | 1.080 | 2.960 |
| Total Phosphorous | 6 | 5 | mg/L | 0.500 | 0.110 | 2.380 |
| E-Coli | 4 | 3 | CH | 18200.* | 1280. | 259000. |
| Fecal Coliform MF | 4 | 3 | CH | 21900.* | 1490. | 322000. |
| Fecal Streptroccus MF | 4 | 4 | CH | 52900.* | 4270. | 655000. |
| Pseudomonas Aeruginosa MF | 4 | 3 | CH | 34900.* | 984. | 1240000. |
| Silver | 6 | 4 | mg/L | 0.005 | 0.001 | 0.034 |
| Aluminum | 6 | 6 | mg/L | 6.650 | 0.880 | 50.300 |
| Arsenic | 6 | 1 | mg/L | 0.001# | | |
| Barium | 6 | 6 | mg/L | 0.074 | 0.063 | 0.087 |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 6 | 4 | mg/L | 0.001 | 0.000 | 0.002 |
| Chromium | 6 | 6 | mg/L | 0.011 | 0.009 | 0.014 |
| Copper | 6 | 5 | mg/L | 0.066* | 0.034 | 0.130 |
| Iron | 6 | 6 | mg/L | 12.600 | 1.690 | 93.900 |
| Mercury | 6 | 5 | ug/L | 0.088 | 0.031 | 0.250 |
| Manganese | 6 | 6 | mg/L | 0.250 | 0.120 | 0.520 |
| Nickel | 6 | 6 | mg/L | 0.028 | 0.009 | 0.085 |
| Lead | 6 | 6 | mg/L | 0.084 | 0.052 | 0.140 |
| Selenium | 6 | 1 | mg/L | 0.001# | | |
| Zinc | 6 | 6 | mg/L | 0.300 | 0.081 | 1.110 |
| Alpha-BHC | 3 | 3 | ng/L | 3.300 | 2.190 | 4.970 |
| Gamma-BHC | 3 | 3 | ng/L | 2.850 | 0.870 | 9.290 |
| 1,2,4-Trichlorobenzene | | | ng/L | NC | | |
| 1,2,3-Trichlorobenzene | 3 | 1 | ng/L | 0.910# | | |

NOTE: * regression used, # traditional method used
      CH = counts/100 mL

**TABLE A3.2** Estimated Event Mean Concentration for water quality parameters by Land use

Residential Stations (#4, #10, #11)

| Parameter | N | ND | Units | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | 22 | 22 | mg/L | 63.300 | 58.000 | 69.100 |
| Biochemical Oxygen Demand (5 day) | 1 | 1 | mg/L | 665.000# | | |
| Cyanide - Avl. Unfil. React. | 21 | 5 | mg/L | 0.007# | | |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | 1 | 1 | mg/L | 5.200# | | |
| Chemical Oxygen Demand | 21 | 21 | mg/L | 724.000 | 395.000 | 1330.000 |
| Dissolved Organic Carbon | 1 | 1 | mg/L | 333.000# | | |
| Hardness | 3 | 3 | mg/L | 106.000 | 52.700 | 213.000 |
| Phenolics (4AAP) | 21 | 21 | ug/L | 17.400 | 15.700 | 19.300 |
| Total dissolved solids | 1 | 1 | mg/L | 52.000# | | |
| Total suspended solids | 21 | 21 | mg/L | 88.600 | 68.500 | 115.000 |
| Total solids | 21 | 21 | mg/L | 307.000 | 249.000 | 378.000 |
| Solvent extractable (organic) | 21 | 20 | mg/L | 7.910 | 5.750 | 10.900 |
| Sulphide | | | ug/L | NC | | |
| Ammonium | 24 | 4 | mg/L | 0.480# | | |
| Nitrates | 24 | 18 | mg/L | 3.660 | 0.350 | 38.000 |
| Nitrite | 21 | 16 | mg/L | 0.037 | 0.016 | 0.088 |
| Total Keljehl Nitrogen | 24 | 24 | mg/L | 2.370 | 1.800 | 3.120 |
| Total Phosphorous | 24 | 24 | mg/L | 0.420 | 0.320 | 0.550 |
| E-Coli | 15 | 15 | CH | 155000. | 10000. | 2400000. |
| Fecal Coliform MF | 14 | 14 | CH | 289000. | 11500. | 7250000. |
| Fecal Streptroccus MF | 15 | 15 | CH | 22300. | 8250. | 60300. |
| Pseudomonas Aeruginosa MF | 15 | 15 | CH | 222. | 184. | 268. |
| Silver | 24 | 15 | mg/L | 0.003 | 0.001 | 0.007 |
| Aluminum | 24 | 24 | mg/L | 1.380 | 0.910 | 2.090 |
| Arsenic | 24 | 4 | mg/L | 0.001# | | |
| Barium | 24 | 24 | mg/L | 0.026 | 0.020 | 0.034 |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 24 | 9 | mg/L | 0.001 | 0.000 | 0.005 |
| Chromium | 24 | 20 | mg/L | 0.009 | 0.004 | 0.016 |
| Copper | 24 | 24 | mg/L | 0.027 | 0.017 | 0.043 |
| Iron | 24 | 24 | mg/L | 2.950 | 2.080 | 4.190 |
| Mercury | 24 | 23 | ug/L | 0.051 | 0.041 | 0.063 |
| Manganese | 24 | 24 | mg/L | 0.120 | 0.093 | 0.150 |
| Nickel | 24 | 21 | mg/L | 0.007 | 0.005 | 0.010 |
| Lead | 24 | 23 | mg/L | 0.037 | 0.029 | 0.047 |
| Selenium | 24 | 1 | mg/L | 0.001# | | |
| Zinc | 24 | 24 | mg/L | 0.120 | 0.110 | 0.140 |
| Alpha-BHC | 19 | 19 | ng/L | 2.170 | 2.000 | 2.350 |
| Gamma-BHC | 19 | 19 | ng/L | 1.370 | 1.150 | 1.640 |
| 1,2,4-Trichlorobenzene | 19 | 11 | ng/L | 3.250* | 1.650 | 6.420 |
| 1,2,3-Trichlorobenzene | 19 | 10 | ng/L | 2.590 | 0.210 | 32.200 |

NOTE: * regression used, # traditional method used
CH = counts/100 mL

**TABLE A3.3** Estimated Event Mean Concentration for water quality parameters by Land use

| Parameter | N | ND | Units | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | Industrial Stations (#3, #5, #9) | | | |
| Alkalinity (as CaCO3) | 13 | 13 | mg/L | 110.000 | 102.000 | 118.000 |
| Biochemical Oxygen Demand (5 day) | 1 | 1 | mg/L | 172.000# | | |
| Cyanide - Avl. Unfil. React. | 15 | 2 | mg/L | 0.002# | | |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | | | mg/L | NC | | |
| Chemical Oxygen Demand | 13 | 13 | mg/L | 837.000 | 574.000 | 1220.000 |
| Dissolved Organic Carbon | | | mg/L | NC | | |
| Hardness | 2 | 2 | mg/L | 318.000# | | |
| Phenolics (4AAP) | 14 | 14 | ug/L | 14.300 | 10.000 | 20.400 |
| Total dissolved solids | | | mg/L | NC | | |
| Total suspended solids | 13 | 13 | mg/L | 172.000 | 48.500 | 611.000 |
| Total solids | 13 | 13 | mg/L | 468.000 | 415.000 | 528.000 |
| Solvent extractable (organic) | 10 | 7 | mg/L | 9.680 | 2.510 | 37.300 |
| Sulphide | 2 | 1 | ug/L | 2.000# | | |
| Ammonium | 15 | 7 | mg/L | 0.190 | 0.046 | 0.780 |
| Nitrates | 15 | 13 | mg/L | 10.100 | 0.910 | 112.000 |
| Nitrite | 13 | 11 | mg/L | 0.047 | 0.023 | 0.098 |
| Total Keljehl Nitrogen | 15 | 15 | mg/L | 2.930 | 1.750 | 4.900 |
| Total Phosphorous | 15 | 15 | mg/L | 0.650 | 0.230 | 1.860 |
| E-Coli | 10 | 10 | CH | 38800.* | 6300. | 239000. |
| Fecal Coliform MF | 10 | 10 | CH | 38300.* | 6800. | 216000. |
| Fecal Streptroccus MF | 10 | 9 | CH | 320000.* | 35000. | 2930000. |
| Pseudomonas Aeruginosa MF | 10 | 7 | CH | 5570.* | 736. | 42100. |
| Silver | 18 | 14 | mg/L | 0.002 | 0.002 | 0.004 |
| Aluminum | 18 | 18 | mg/L | 1.570 | 0.940 | 2.620 |
| Arsenic | 18 | 2 | mg/L | 0.002# | | |
| Barium | 18 | 18 | mg/L | 0.051 | 0.044 | 0.059 |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 18 | 12 | mg/L | 0.018 | 0.001 | 0.310 |
| Chromium | 18 | 16 | mg/L | 0.027 | 0.009 | 0.077 |
| Copper | 18 | 17 | mg/L | 0.460* | 0.180 | 1.180 |
| Iron | 18 | 17 | mg/L | 5.470 | 1.560 | 19.200 |
| Mercury | 18 | 13 | ug/L | 0.039 | 0.024 | 0.063 |
| Manganese | 18 | 18 | mg/L | 0.130 | 0.100 | 0.160 |
| Nickel | 18 | 18 | mg/L | 0.015 | 0.010 | 0.022 |
| Lead | 18 | 18 | mg/L | 0.048 | 0.036 | 0.064 |
| Selenium | 18 | 3 | mg/L | 0.001# | | |
| Zinc | 18 | 18 | mg/L | 0.320 | 0.120 | 0.830 |
| Alpha-BHC | 16 | 16 | ng/L | 1.270 | 1.070 | 1.510 |
| Gamma-BHC | 16 | 14 | ng/L | 0.520 | 0.360 | 0.750 |
| 1,2,4-Trichlorobenzene | 16 | 9 | ng/L | 3.200 | 0.410 | 25.100 |
| 1,2,3-Trichlorobenzene | 16 | 6 | ng/L | 6.320* | 1.740 | 23.000 |

NOTE: * regression used, # traditional method used
      CH = counts/100 mL

**TABLE A3.4** Estimated Event Mean Concentration for water quality parameters by Land use

|  | CSOs Stations (#7 & #8) | | | | Confidence Interval | |
| Parameter | N | ND | Units | Mean | | |
| Alkalinity (as CaCO3) | 15 | 15 | mg/L | 112.000 | 102.000 | 123.000 |
| Biochemical Oxygen Demand (5 day) | | | mg/L | NC | | |
| Cyanide - Avl. Unfil. React. | 14 | 5 | mg/L | 27400.000* | 2960.000 | 253000.000 |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | | | mg/L | NC | | |
| Chemical Oxygen Demand | 14 | 14 | mg/L | 857.000 | 322.000 | 2280.000 |
| Dissolved Organic Carbon | | | mg/L | NC | | |
| Hardness | | | mg/L | NC | | |
| Phenolics (4AAP) | 13 | 13 | ug/L | 19.200 | 17.500 | 21.000 |
| Total dissolved solids | | | mg/L | NC | | |
| Total suspended solids | 14 | 14 | mg/L | 115.000 | 84.800 | 156.000 |
| Total solids | 14 | 14 | mg/L | 538.000 | 450.000 | 642.000 |
| Solvent extractable (organic) | 13 | 13 | mg/L | 9.950 | 6.940 | 14.300 |
| Sulphide | | | ug/L | NC | | |
| Ammonium | 16 | 1 | mg/L | 0.048# | | |
| Nitrates | 16 | 11 | mg/L | 0.530 | 0.160 | 1.730 |
| Nitrite | 14 | 10 | mg/L | 0.055 | 0.012 | 0.260 |
| Total Keljehl Nitrogen | 16 | 16 | mg/L | 2.540 | 2.150 | 3.010 |
| Total Phosphorous | 16 | 16 | mg/L | 0.550 | 0.390 | 0.770 |
| E-Coli | 10 | -10 | CH | 445000. | 17700. | 11200000. |
| Fecal Coliform MF | 10 | 10 | CH | 543000. | 29600. | 9970000. |
| Fecal Streptroccus MF | 10 | 10 | CH | 45200. | 19000. | 107000. |
| Pseudomonas Aeruginosa MF | 10 | 10 | CH | 1830. | 534. | 6270. |
| Silver | 17 | 9 | mg/L | 0.003 | 0.001 | 0.010 |
| Aluminum | 17 | 17 | mg/L | 1.490 | 1.150 | 1.930 |
| Arsenic | 17 | 2 | mg/L | 0.001# | | |
| Barium | 17 | 17 | mg/L | 0.057 | 0.047 | 0.068 |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 17 | 8 | mg/L | 0.001 | 0.000 | 0.002 |
| Chromium | 17 | 14 | mg/L | 0.011 | 0.006 | 0.021 |
| Copper | 17 | 17 | mg/L | 0.064 | 0.033 | 0.120 |
| Iron | 17 | 17 | mg/L | 4.870 | 3.140 | 7.550 |
| Mercury | 17 | 17 | ug/L | 0.081 | 0.065 | 0.100 |
| Manganese | 17 | 17 | mg/L. | 0.300 | 0.190 | 0.480 |
| Nickel | 17 | 15 | mg/L | 0.010 | 0.006 | 0.014 |
| Lead | 17 | 17 | mg/L | 0.063 | 0.049 | 0.081 |
| Selenium | 17 | 3 | mg/L | 0.001# | | |
| Zinc | 17 | 17 | mg/L | 0.170 | 0.140 | 0.210 |
| Alpha-BHC | 13 | 13 | ng/L | 2.110 | 1.900 | 2.340 |
| Gamma-BHC | 13 | 13 | ng/L | 2.360 | 1.730 | 3.220 |
| 1,2,4-Trichlorobenzene | 13 | 9 | ng/L | 2.840 | 0.700 | 11.600 |
| 1,2,3-Trichlorobenzene | 13 | 7 | ng/L | 1.820* | 0.780 | 4.230 |

NOTE: * regression used, # traditional method used
     CH = counts/100 mL

**TABLE A3.5** Estimated Event Mean Concentration for water quality parameters for catchments with no CSOs

| Parameter | N | ND | Units | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Alkalinity (as CaCO3) | 41 | 41 | mg/L | 83.600 | 77.000 | 90.800 |
| Biochemical Oxygen Demand (5 day) | 2 | 2 | mg/L | 419.000# | | |
| Cyanide - Avl. Unfil. React. | 41 | 8 | mg/L | 0.005# | | |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | 1 | 1 | mg/L | 5.200# | | |
| Chemical Oxygen Demand | 40 | 40 | mg/L | 740.000 | 527.000 | 1040.000 |
| Dissolved Organic Carbon | 2 | 1 | mg/L | 166.000# | | |
| Hardness | 5 | 5 | mg/L | 210.000 | 94.300 | 467.000 |
| Phenolics (4AAP) | 41 | 41 | ug/L | 16.300 | 14.100 | 18.800 |
| Total dissolved solids | 1 | 1 | mg/L | 52.000# | | |
| Total suspended solids | 40 | 40 | mg/L | 128.000 | 87.100 | 188.000 |
| Total solids | 40 | 40 | mg/L | 421.000 | 361.000 | 491.000 |
| Solvent extractable (organic) | 36 | 31 | mg/L | 7.950 | 5.520 | 11.400 |
| Sulphide | 3 | 1 | ug/L | 1.330# | | |
| Ammonium | 45 | 14 | mg/L | 0.270 | 0.050 | 1.470 |
| Nitrates | 45 | 37 | mg/L | 4.890 | 1.140 | 20.900 |
| Nitrite | 40 | 33 | mg/L | 0.052 | 0.029 | 0.093 |
| Total Keljehl Nitrogen | 45 | 45 | mg/L | 2.420 | 1.940 | 3.030 |
| Total Phosphorous | 45 | 44 | mg/L | 0.490 | 0.340 | 0.710 |
| E-Coli | 29 | 28 | CH | 177000.* | 60900. | 514000. |
| Fecal Coliform MF | 28 | 27 | CH | 403000.* | 10000. | 16200000. |
| Fecal Streptroccus MF | 29 | 28 | CH | 67900.* | 27300. | 169000. |
| Pseudomonas Aeruginosa MF | 29 | 25 | CH | 492.* | 265. | 913. |
| Silver | 48 | 33 | mg/L | 0.003 | 0.002 | 0.005 |
| Aluminum | 48 | 48 | mg/L | 1.760 | 1.240 | 2.510 |
| Arsenic | 48 | 7 | mg/L | 0.001# | | |
| Barium | 48 | 48 | mg/L | 0.043 | 0.035 | 0.052 |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 48 | 25 | mg/L | 0.005 | 0.001 | 0.024 |
| Chromium | 48 | 42 | mg/L | 0.015 | 0.009 | 0.025 |
| Copper | 48 | 46 | mg/L | 0.160 | 0.056 | 0.460 |
| Iron | 48 | 47 | mg/L | 4.420 | 2.700 | 7.240 |
| Mercury | 48 | 41 | ug/L | 0.050 | 0.040 | 0.063 |
| Manganese | 48 | 48 | mg/L | 0.140 | 0.120 | 0.170 |
| Nickel | 48 | 45 | mg/L | 0.012 | 0.009 | 0.016 |
| Lead | 48 | 47 | mg/L | 0.046 | 0.038 | 0.055 |
| Selenium | 48 | 5 | mg/L | 0.001# | | |
| Zinc | 48 | 48 | mg/L | 0.190 | 0.140 | 0.260 |
| Alpha-BHC | 38 | 38 | ng/L | 1.880 | 1.670 | 2.120 |
| Gamma-BHC | 38 | 36 | ng/L | 1.140 | 0.850 | 1.530 |
| 1,2,4-Trichlorobenzene | 38 | 20 | ng/L | 6.010 | 0.950 | 38.200 |
| 1,2,3-Trichlorobenzene | 38 | 17 | ng/L | 2.430* | 1.200 | 4.910 |

NOTE: * regression used, # traditional method used
CH = counts/100 mL

## TABLE A3.6 ESTIMATED EVENT MEAN CONCENTRATION FOR WATER QUALITY PARAMETERS FOR THE MAIN STP BY-PASS

| Parameter | N | ND | Units | Mean | Confidence | Interval |
|---|---|---|---|---|---|---|
| Alkalinity (as CaCO$_3$) | 2 | 2 | mg/L | 283* | | |
| Biochemical Oxygen Demand (5-day) | | | mg/L | NC | | |
| Cyanide - Avl. Unfil. React. | 2 | 2 | mg/L | 0.080* | | |
| Cyanide - Free Unfil. React. | | | mg/L | NC | | |
| Chlorine | | | mg/L | NC | | |
| Chemical Oxygen Demand | 2 | 2 | mg/L | 247* | | |
| Dissolved Organic Carbon | | | mg/L | NC | | |
| Hardness | | | mg/L | NC | | |
| Phenolics (4AAP) | 2 | 2 | μg/L | 158* | | |
| Total Dissolved Solids | | | mg/L | NC | | |
| Total Suspended Solids | 2 | 2 | mg/L | 359* | | |
| Total Solids | 2 | 2 | mg/L | 763* | | |
| Solvent Extractable (organic) | 2 | 2 | mg/L | 41.5* | | |
| Sulphide | | | μg/L | NC | | |
| Ammonium | 2 | 2 | mg/L | 29* | | |
| Nitrates | 2 | 1 | mg/L | 0.087* | | |
| Nitrite | 2 | 2 | mg/L | 0.010* | | |
| Total Kjeldahl Nitrogen | 2 | 2 | mg/L | 57.7* | | |
| Total Phosphorus | 2 | 2 | mg/L | 16.1* | | |
| E-Coli | 2 | 2 | CH | 4,650,000* | | |
| Fecal Coliform MF | 2 | 2 | CH | 5,900,000* | | |
| Fecal Streptococcus MF | 2 | 2 | CH | 590,000* | | |
| Pseudomonas aeruginosa MF | 2 | 2 | CH | 56,500* | | |
| Silver | 2 | 2 | mg/L | 0.083* | | |
| Aluminum | 2 | 2 | mg/L | 3.050* | | |
| Arsenic | | | mg/L | NC | | |
| Barium | 2 | 2 | mg/L | 0.260* | | |
| Beryllium | | | mg/L | NC | | |
| Cadmium | 2 | 2 | mg/L | 0.012* | | |
| Chromium | 2 | 2 | mg/L | 0.330* | | |
| Copper | 2 | 2 | mg/L | 0.500* | | |
| Iron | 2 | 2 | mg/L | 32.5* | | |
| Mercury | 2 | 2 | μg/L | 0.510* | | |
| Manganese | 2 | 2 | mg/L | 0.200* | | |
| Nickel | 2 | 2 | mg/L | 0.056* | | |
| Lead | 2 | 2 | mg/L | 0.130* | | |
| Selenium | | | mg/L | NC | | |
| Zinc | 2 | 2 | mg/L | 0.770* | | |
| Alpha BHC | 3 | 2 | ng/L | 0.570* | | |
| Gamma BHC | 3 | 3 | ng/L | 2.130 | 0.830 | 5.460 |
| 1,2,4-Trichlorobenzene | 3 | 2 | ng/L | 5.110* | | |
| 1,2,3-Trichlorobenzene | | | ng/L | NC | | |

\* traditional method used.
CH = counts/100 mL.

TABLE A3.7  Estimated Mean Event Concentrations for Station 3-L308
         for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 5 | 5 | 351# | | |
| Acenapthylene | ng/L | 5 | 1 | 3.66# | | |
| Acenapthene | ng/L | 5 | 3 | 140* | 57.7 | 340 |
| Fluorene | ng/L | 5 | 3 | 189* | 94.5 | 378 |
| Phenanthrene | ng/L | 5 | 4 | 1050* | 335 | 3290 |
| Anthracene | ng/L | 5 | 4 | 44.1# | | |
| Fluoranthene | ng/L | 5 | 5 | 1050# | | |
| Pyrene | ng/L | 5 | 5 | 384# | | |
| Benzo (A) Anthracene | ng/L | 5 | 4 | 411* | 98.9 | 1710 |
| Chrysene | ng/L | 5 | 5 | 380# | | |
| Benzo (B) Fluoranthene | ng/L | 5 | 4 | 1170* | 195 | 7010 |
| Benzo (B-K) Fluoranthene | ng/L | 5 | 4 | 563* | 119 | 2660 |
| Benzo (A) Pyrene | ng/L | 5 | 3 | 631* | 120 | 3310 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 5 | 3 | 173* | 78.0 | 384 |
| Dibenzo (A-H) Anthracene | ng/L | 5 | 2 | 21.9# | | |
| Benzo (G-H-I) Perylene | ng/L | 5 | 3 | 426* | 109 | 1660 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
     N number of samples, ND number of samples with detected amounts

TABLE A3.8  Estimated Mean Event Concentrations for Station 4-L102
         for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 4 | 4 | 185# | | |
| Acenapthylene | ng/L | 4 | 3 | 7.82 | 6.42 | 9.53 |
| Acenapthene | ng/L | 4 | 4 | 34.0 | 14.7 | 78.4 |
| Fluorene | ng/L | 4 | 4 | 94.4 | 30.7 | 290 |
| Phenanthrene | ng/L | 4 | 4 | 231 | 149 | 358 |
| Anthracene | ng/L | 4 | 4 | 11.7 | 7.56 | 18.1 |
| Fluoranthene | ng/L | 4 | 4 | 368 | 64.9 | 2090 |
| Pyrene | ng/L | 4 | 4 | 232 | 74.9 | 718 |
| Benzo (A) Anthracene | ng/L | 4 | 3 | 56.7 | 9.48 | 339 |
| Chrysene | ng/L | 4 | 3 | 111* | 64.2 | 192 |
| Benzo (B) Fluoranthene | ng/L | 4 | 3 | 82.8* | 66.4 | 103 |
| Benzo (B-K) Fluoranthene | ng/L | 4 | 3 | 68.3 | 9.51 | 491 |
| Benzo (A) Pyrene | ng/L | 4 | 3 | 89.4 | 11.5 | 695 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 4 | 2 | 58.5# | | |
| Dibenzo (A-H) Anthracene | ng/L | 4 | 2 | 4.88# | | |
| Benzo (G-H-I) Perylene | ng/L | 4 | 3 | 42.1* | 29.2 | 60.7 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
     N number of samples, ND number of samples with detected amounts

TABLE A3.9   Estimated Mean Event Concentrations for Station 7-Cecil CSO
for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 11 | 11 | 138 | 88.0 | 216 |
| Acenapthylene | ng/L | 11 | 11 | 18.3 | 16.6 | 20.2 |
| Acenapthene | ng/L | 11 | 11 | 47.8 | 42.3 | 54.0 |
| Fluorene | ng/L | 11 | 11 | 97.2 | 80.4 | 117 |
| Phenanthrene | ng/L | 11 | 11 | 931 | 667 | 1300 |
| Anthracene | ng/L | 11 | 11 | 45.0 | 25.5 | 79.5 |
| Fluoranthene | ng/L | 11 | 11 | 1220 | 934 | 1590 |
| Pyrene | ng/L | 11 | 11 | 923 | 738 | 1150 |
| Benzo (A) Anthracene | ng/L | 11 | 11 | 255 | 197 | 330 |
| Chrysene | ng/L | 11 | 11 | 494 | 407 | 599 |
| Benzo (B) Fluoranthene | ng/L | 11 | 11 | 548 | 442 | 680 |
| Benzo (B-K) Fluoranthene | ng/L | 11 | 11 | 344 | 244 | 485 |
| Benzo (A) Pyrene | ng/L | 11 | 11 | 276 | 234 | 326 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 11 | 11 | 338 | 243 | 469 |
| Dibenzo (A-H) Anthracene | ng/L | 11 | 10 | 183 | 37.0 | 905 |
| Benzo (G-H-I) Perylene | ng/L | 11 | 11 | 343 | 272 | 432 |

Notes: * regression estimate used. # traditional method used, Cu=0.5DL, ** no data
N number of samples, ND number of samples with detected amounts

TABLE A3.10   Estimated Mean Event Concentrations for Station 8-E11
for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval |
|---|---|---|---|---|---|
| Napthalene | ng/L | 2 | 2 | 293# | |
| Acenapthylene | ng/L | 2 | 2 | 15.5# | |
| Acenapthene | ng/L | 2 | 2 | 33.6# | |
| Fluorene | ng/L | 2 | 2 | 56.7# | |
| Phenanthrene | ng/L | 2 | 2 | 383# | |
| Anthracene | ng/L | 2 | 2 | 20.1# | |
| Fluoranthene | ng/L | 2 | 2 | 677# | |
| Pyrene | ng/L | 2 | 2 | 608# | |
| Benzo (A) Anthracene | ng/L | 2 | 2 | 296# | |
| Chrysene | ng/L | 2 , | 2 | 417# | |
| Benzo (B) Fluoranthene | ng/L | 2 | 2 | 607# | |
| Benzo (B-K) Fluoranthene | ng/L | 2 | 2 | 281# | |
| Benzo (A) Pyrene | ng/L | 2 | 2 | 282# | |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 2 | 2 | 233# | |
| Dibenzo (A-H) Anthracene | ng/L | 2 | 1 | 57.0# | |
| Benzo (G-H-I) Perylene | ng/L | 2 | 2 | 263# | |

Notes: * regression estimate used. # traditional method used, Cu=0.5DL, ** no data
N number of samples, ND number of samples with detected amounts

TABLE A3.11    Estimated Mean Event Concentrations for Station 5-Brown's Line
for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 4 | 4 | 385 | 4.16 | 35700 |
| Acenapthylene | ng/L | 4 | 2 | 22.3# | | |
| Acenapthene | ng/L | 4 | 4 | 37.4 | 3.88 | 360 |
| Fluorene | ng/L | 4 | 4 | 88.5 | 9.64 | 813 |
| Phenanthrene | ng/L | 4 | 4 | 573 | 58.5 | 5620 |
| Anthracene | ng/L | 4 | 4 | 24.0 | 8.46 | 68.1 |
| Fluoranthene | ng/L | 4 | 4 | 645 | 170 | 2450 |
| Pyrene | ng/L | 4 | 4 | 533 | 176 | 1610 |
| Benzo (A) Anthracene | ng/L | 4 | 4 | 115 | 47.2 | 280 |
| Chrysene | ng/L | 4 | 4 | 271 | 69.7 | 1050 |
| Benzo (B) Fluoranthene | ng/L | 4 | 4 | 273 | 92.0 | 810 |
| Benzo (B-K) Fluoranthene | ng/L | 4 | 4 | 165 | 43.3 | 628 |
| Benzo (A) Pyrene | ng/L | 4 | 4 | 178 | 61.3 | 517 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 4 | 4 | 196 | 59.0 | 651 |
| Dibenzo (A-H) Anthracene | ng/L | 4 | 2 | 3.37# | | |
| Benzo (G-H-I) Perylene | ng/L | 4 | 4 | 153 | 54.4 | 430 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
N number of samples, ND number of samples with detected amounts


TABLE A3.12    Estimated Mean Event Concentrations for Station 6-Kingston Road
for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 3 | 3 | 198 | 191 | 206 |
| Acenapthylene | ng/L | 3 | 3 | 47.1 | 35.9 | 61.7 |
| Acenapthene | ng/L | 3 | 3 | 48.5 | 46.9 | 50.1 |
| Fluorene | ng/L | 3 | 3 | 91.2 | 82.7 | 101 |
| Phenanthrene | ng/L | 3 | 3 | 523 | 448 | 611 |
| Anthracene | ng/L | 3 | 2 | 37.6# | | |
| Fluoranthene | ng/L | 3 | 3 | 690 | 606 | 786 |
| Pyrene | ng/L | 3 | 3 | 619 | 535 | 716 |
| Benzo (A) Anthracene | ng/L | 3 | 3 | 436 | 120 | 1580 |
| Chrysene | ng/L | 3, | 3 | 332 | 329 | 335 |
| Benzo (B) Fluoranthene | ng/L | 3 | 3 | 261 | 192 | 355 |
| Benzo (B-K) Fluoranthene | ng/L | 3 | 3 | 216 | 155 | 301 |
| Benzo (A) Pyrene | ng/L | 3 | 3 | 195 | 185 | 206 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 3 | 3 | 162 | 40.3 | 652 |
| Dibenzo (A-H) Anthracene | ng/L | 3 | 1 | 9.33# | | |
| Benzo (G-H-I) Perylene | ng/L | 3 | 3 | 261 | 51.6 | 1320 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
N number of samples, ND number of samples with detected amounts

TABLE A3.13   Estimated Mean Event Concentrations for Station 9-Beachgrove
             for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 7 | 7 | 29.0 | 4.87 | 173 |
| Acenapthylene | ng/L | 7 | 4 | 1.43* | 0.510 | 4.02 |
| Acenapthene | ng/L | 7 | 6 | 4.79 | 2.14 | 10.7 |
| Fluorene | ng/L | 7 | 6 | 8.00 | 3.28 | 19.5 |
| Phenanthrene | ng/L | 7 | 7 | 14.7 | 7.59 | 28.5 |
| Anthracene | ng/L | 7 | 5 | 13.3 | 1.89 | 93.8 |
| Fluoranthene | ng/L | 7 | 7 | 30.1 | 19.4 | 46.8 |
| Pyrene | ng/L | 7 | 7 | 40.3 | 27.4 | 59.4 |
| Benzo (A) Anthracene | ng/L | 7 | 6 | 10.1 | 5.79 | 17.6 |
| Chrysene | ng/L | 7 | 7 | 19.0 | 11.1 | 32.5 |
| Benzo (B) Fluoranthene | ng/L | 7 | 3 | 8.86# | | |
| Benzo (B-K) Fluoranthene | ng/L | 7 | 2 | 6.43# | | |
| Benzo (A) Pyrene | ng/L | 7 | 1 | 6.03# | | |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 7 | 1 | 6.19# | | |
| Dibenzo (A-H) Anthracene | ng/L | 7 | 1 | 1.71# | | |
| Benzo (G-H-I) Perylene | ng/L | 7 | 1 | 6.19# | | |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
       N number of samples, ND number of samples with detected amounts


TABLE A3.14   Estimated Mean Event Concentrations for Station 10-Kingston Road 2
             for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 6 | 6 | 287 | 14.9 | 5530 |
| Acenapthylene | ng/L | 6 | 3 | 24.8 | 3.78 | 163 |
| Acenapthene | ng/L | 6 | 6 | 58.7 | 12.6 | 273 |
| Fluorene | ng/L | 6 | 6 | 115 | 23.7 | 559 |
| Phenanthrene | ng/L | 6 | 6 | 650 | 234 | 1810 |
| Anthracene | ng/L | 6 | 5 | 147 | 5.34 | 4040 |
| Fluoranthene | ng/L | 6 | 6 | 1150 | 516 | 2560 |
| Pyrene | ng/L | 6 | 6 | 960 | 431 | 2140 |
| Benzo (A) Anthracene | ng/L | 6 | 6 | 418 | 167 | 1050 |
| Chrysene | ng/L | 6 | 5 | 604* | 251 | 1460 |
| Benzo (B) Fluoranthene | ng/L | 6, | 5 | 1010* | 323 | 3160 |
| Benzo (B-K) Fluoranthene | ng/L | 6 | 5 | 1240 | 30.6 | 50200 |
| Benzo (A) Pyrene | ng/L | 6 | 6 | 466 | 122 | 1780 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 6 | 5 | 527* | 157 | 1760 |
| Dibenzo (A-H) Anthracene | ng/L | 6 | 4 | 268* | 43.4 | 1650 |
| Benzo (G-H-I) Perylene | ng/L | 6 | 5 | 635* | 191 | 2110 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
       N number of samples, ND number of samples with detected amounts

TABLE A3.15   Estimated Mean Event Concentrations for Station 11-Brooklawn
              for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 10 | 10 | 185 | 54.1 | 632 |
| Acenapthylene | ng/L | 10 | 10 | 17.7 | 10.1 | 31.2 |
| Acenapthene | ng/L | 10 | 10 | 222 | 56.7 | 870 |
| Fluorene | ng/L | 10 | 10 | 156 | 83.0 | 293 |
| Phenanthrene | ng/L | 10 | 10 | 810 | 574 | 1140 |
| Anthracene | ng/L | 10 | 9 | 54.2 | 31.3 | 93.9 |
| Fluoranthene | ng/L | 10 | 10 | 1200 | 888 | 1620 |
| Pyrene | ng/L | 10 | 10 | 885 | 641 | 1220 |
| Benzo (A) Anthracene | ng/L | 10 | 10 | 281 | 179 | 442 |
| Chrysene | ng/L | 10 | 10 | 486 | 334 | 707 |
| Benzo (B) Fluoranthene | ng/L | 10 | 10 | 583 | 358 | 949 |
| Benzo (B-K) Fluoranthene | ng/L | 10 | 10 | 768 | 300 | 1960 |
| Benzo (A) Pyrene | ng/L | 10 | 10 | 334 | 219 | 509 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 10 | 10 | 312 | 208 | 469 |
| Dibenzo (A-H) Anthracene | ng/L | 10 | 8 | 105 | 16.2 | 681 |
| Benzo (G-H-I) Perylene | ng/L | 10 | 10 | 373 | 220 | 632 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
       N number of samples, ND number of samples with detected amounts

TABLE A3.16    Estimated Mean Event Concentrations for all stations (3 to 11)
              lumped together for polynuclear aromatic hydrocarbons

| Parameter Name | Units | N | ND | Mean | Confidence Interval | |
|---|---|---|---|---|---|---|
| Napthalene | ng/L | 52 | 52 | 254 | 116 | 558 |
| Acenapthylene | ng/L | 52 | 39 | 17.6 | 11.8 | 26.4 |
| Acenapthene | ng/L | 52 | 49 | 86.3 | 43.7 | 171 |
| Fluorene | ng/L | 52 | 49 | 136 | 72.0 | 257 |
| Phenanthrene | ng/L | 52 | 51 | 1130 | 493 | 2590 |
| Anthracene | ng/L | 52 | 46 | 47.1 | 26.8 | 82.9 |
| Fluoranthene | ng/L | 52 | 52 | 1530 | 710 | 3300 |
| Pyrene | ng/L | 52 | 52 | 1030 | 547 | 1940 |
| Benzo (A) Anthracene | ng/L | 52 | 49 | 341 | 171 | 680 |
| Chrysene | ng/L | 52 | 50 | 677 | 301 | 1520 |
| Benzo (B) Fluoranthene | ng/L | 52 | 45 | 1100 | 358 | 3380 |
| Benzo (B-K) Fluoranthene | ng/L | 52 | 44 | 723 | 240 | 2180 |
| Benzo (A) Pyrene | ng/L | 52 | 43 | 499 | 198 | 1260 |
| Indeno (1-2-3 C-D) Pyrene | ng/L | 52 | 41 | 240* | 176 | 328 |
| Dibenzo (A-H) Anthracene | ng/L | 52 | 31 | 113* | 60.3 | 212 |
| Benzo (G-H-I) Perylene | ng/L | 52 | 42 | 285* | 203 | 400 |

Notes: * regression estimate used, # traditional method used, Cu=0.5DL, ** no data
       N number of samples, ND number of samples with detected amounts

**APPENDIX 4**

# TABLE A4.1    PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR ETOBICOKE

| PARAMETER | UNITS | E1 L102 | E2 L103 | E3 L104,L105 | E4 L201,L202 L203A | E5 L203B,L204 L205 | E6 L301 | E7 L302,L303,L304 L305,L306,L307 | E8 L308,L309 | E9 L401,L402 L403 | E10 L403C | E11 L404 | E12 L405,L406, L407,L408 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | | | | | | | | | |
| Chemical Oxygen Demand | T | 21.80 | 13.20 | 19.80 | 122.00 | 668.00 | 10.24 | 51.20 | 241.00 | 57.50 | 284.00 | 67.30 | 22.86 |
| Hardness | T | 6.01 | 3.63 | 5.46 | 33.70 | 184.00 | 2.83 | 14.10 | 66.60 | 15.90 | 78.50 | 18.60 | 6.31 |
| Phenolics (4AAP) | g | 489.00 | 296.00 | 445.00 | 2,740.00 | 15,023.00 | 231.00 | 1,150.00 | 5,420.00 | 1,290.00 | 6,390.00 | 1,510.00 | 512.30 |
| Total suspended solids | T | 3.55 | 2.15 | 3.22 | 19.90 | 109.00 | 1.67 | 8.35 | 39.30 | 9.37 | 46.30 | 11.00 | 3.73 |
| Ammonium | g | 6,860.00 | 4,150.00 | 6,240.00 | 38,500.00 | 211,554.00 | 3,243.00 | 16,200.00 | 76,100.00 | 18,100.00 | 89,700.00 | 21,200.00 | 7,193.00 |
| Nitrates | kg | 90.10 | 54.50 | 81.90 | 505.00 | 2,774.00 | 42.50 | 212.00 | 999.00 | 238.00 | 1,180.00 | 279.00 | 94.70 |
| Nitrite | g | 1,490.00 | 900.00 | 1,350.00 | 8,340.00 | 45,683.00 | 702.20 | 3,500.00 | 16,500.00 | 3,930.00 | 19,400.00 | 4,600.00 | 1,560.00 |
| Total Kjeldhal Nitrogen | kg | 70.40 | 42.60 | 64.00 | 394.00 | 2,161.00 | 33.20 | 163.00 | 780.00 | 186.00 | 919.00 | 218.00 | 74.00 |
| Total Phosphorus | kg | 14.60 | 8.82 | 13.30 | 81.80 | 447.00 | 6.88 | 34.30 | 162.00 | 38.60 | 191.00 | 45.10 | 15.30 |
| **BACTERIOLOGY** | | | | | | | | | | | | | |
| E-Coli | TCts | 1,080,000.00* | 656,000.00* | 985,000.00* | 6,080,000.00* | 33,270,000.00* | 511,000.00* | 2,550,000.00* | 11,999,999.00* | 2,870,000.00* | 14,200,000.00* | 3,350,000.00* | 1,130,000.00* |
| Fecal Coliform MF | TCts | 1,550,000.00* | 939,000.00* | 1,410,000.00* | 8,700,000.00* | 47,670,000.00* | 733,000.00* | 3,650,000.00* | 17,200,000.00* | 4,110,000.25* | 20,300,000.00* | 4,810,000.00* | 1,630,000.00* |
| **HEAVY METALS** | | | | | | | | | | | | | |
| Silver | g | 85.80 | 51.90 | 78.00 | 481.00 | 2,636.00 | 40.74 | 202.00 | 951.00 | 227.00 | 1,120.00 | 266.00 | 90.25 |
| Aluminum | kg | 48.00 | 29.10 | 43.70 | 269.00 | 1,476.00 | 22.65 | 113.00 | 533.00 | 127.00 | 628.00 | 149.00 | 50.50 |
| Arsenic | g | 28.60# | 17.30# | 26.00# | 160.00# | 878.00# | 13.50# | 67.30# | 317.00# | 75.60# | 374.00# | 88.50# | 30.00# |
| Barium | g | 1,340.00 | 813.00 | 1,220.00 | 7,530.00 | 41,237.00 | 634.00 | 3,160.00 | 14,900.00 | 3,550.00 | 17,600.00 | 4,160.00 | 1,411.00 |
| Cadmium | g | 85.80 | 51.90 | 78.00 | 481.00 | 2,636.00 | 40.70 | 202.00 | 951.00 | 227.00 | 1,120.00 | 266.00 | 90.30 |
| Chromium | g | 400.00 | 242.00 | 364.00 | 2,240.00 | 12,294.00 | 189.00 | 942.00 | 4,440.00 | 1,060.00 | 5,230.00 | 1,240.00 | 420.00 |
| Copper | g | 3,430.00 | 2,080.00 | 3,120.00 | 19,200.00 | 105,470.00 | 1,621.00 | 8,080.00 | 38,000.00 | 9,070.00 | 44,800.00 | 10,600.00 | 3,596.00 |
| Iron | kg | 131.00 | 79.40 | 119.00 | 736.00 | 4,031.00 | 62.00 | 309.00 | 1,460.00 | 347.00 | 1,720.00 | 406.00 | 138.00 |
| Mercury | mg | 1,690.00 | 1,020.00 | 1,530.00 | 9,460.00 | 51,815.00 | 799.00 | 3,970.00 | 18,700.00 | 4,460.00 | 22,000.00 | 5,220.00 | 1,771.00 |
| Manganese | kg | 4.86 | 2.94 | 4.42 | 27.30 | 149.30 | 2.30 | 11.40 | 53.90 | 12.90 | 63.50 | 15.00 | 5.09 |
| Nickel | g | 315.00 | 190.00 | 286.00 | 1,760.00 | 9,673.00 | 148.00 | 740.00 | 3,490.00 | 832.00 | 4,110.00 | 973.00 | 330.00 |
| Lead | g | 1,460.00 | 882.00 | 1,330.00 | 8,180.00 | 44,763.00 | 688.00 | 3,430.00 | 16,200.00 | 3,860.00 | 19,100.00 | 4,510.00 | 1,530.00 |
| Selenium | g | 28.60# | 17.30# | 26.00# | 160.00# | 878.00# | 13.50# | 67.30# | 317.00# | 75.60# | 374.00# | 88.50# | 30.00# |
| Zinc | kg | 5.15 | 3.11 | 4.68 | 28.90 | 578.00 | 2.43 | 12.10 | 57.10 | 13.60 | 67.30 | 15.90 | 5.40 |

Notes: * regression estimate used, # traditional method used, Tct=10^12 counts

# TABLE A4.2     PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR ETOBICOKE

| PARAMETER | UNITS | E1<br>L102 | E2<br>L103 | E3<br>L104,L105 | E4<br>L201,L202<br>L203A | E5<br>L203B,L204<br>L205 | E6<br>L301 | E7<br>L302,L303,L304<br>L305,L306,L307 | E8<br>L308,L309 | E9<br>L401,L402<br>L403 | E10<br>L403C | E11<br>L404 | E12<br>L405,L406,<br>L407,L408 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | | | | | | |
| Alpha-BHC | mg | 55.50 | 33.60 | 50.40 | 311.00 | 1,701.00 | 26.22 | 131.00 | 615.00 | 147.00 | 725.00 | 172.00 | 58.36 |
| Gamma-BHC | mg | 42.30 | 25.60 | 38.50 | 237.00 | 1,300.00 | 20.02 | 99.60 | 469.00 | 112.00 | 553.00 | 131.00 | 44.48 |
| 1,3,5-Trichlorobenzene | mg | 58.90 | 35.60 | 53.60 | 330.00 | 1,809.00 | 27.78 | 139.00 | 653.00 | 156.00 | 770.00 | 182.00 | 61.75 |
| 1,2,4-Trichlorobenzene | mg | 134.00 | 80.80 | 121.00 | 749.00 | 4,108.00 | 63.08 | 314.00 | 1,480.00 | 353.00 | 1,750.00 | 413.00 | 140.13 |
| 1,2,3-Trichlorobenzene | mg | 60.10* | 36.30* | 54.60* | 337.00* | 1,840.00 | 28.32 | 141.00* | 666.00* | 159.00* | 785.00* | 186.00* | 63.11 |
| Hexachlorobenzene | mg | 9.11 | 5.51 | 8.29 | 47.23 | 280.13 | 4.30 | 21.45 | 101.03 | 24.09 | 80.31 | 28.17 | 9.56 |
| PP DDE | mg | 4.67 | 2.83 | 4.25 | 24.21 | 143.60 | 2.21 | 10.99 | 51.79 | 12.35 | 41.17 | 14.44 | 4.90 |
| Alpha Chlordane | mg | 19.34 | 11.70 | 17.58 | 100.21 | 594.38 | 9.13 | 45.51 | 214.36 | 51.12 | 170.40 | 59.78 | 20.29 |
| Gamma Chlordane | mg | 17.10 | 10.34 | 15.54 | 88.59 | 525.42 | 8.07 | 40.23 | 189.49 | 45.19 | 150.63 | 52.84 | 17.93 |
| OP DDT | mg | 9.04 | 5.47 | 8.22 | 46.83 | 277.73 | 4.27 | 21.26 | 100.16 | 23.89 | 79.62 | 27.93 | 9.48 |
| PP DDT | mg | 31.28 | 18.92 | 28.43 | 162.07 | 961.25 | 14.76 | 73.60 | 346.66 | 82.67 | 275.58 | 96.67 | 32.81 |
| Dieldrin | mg | 22.76 | 13.77 | 20.69 | 117.94 | 699.49 | 10.74 | 53.56 | 252.26 | 60.16 | 200.54 | 70.35 | 23.87 |
| Hexachloroethane | mg | 5.14 | 3.11 | 4.67 | 26.63 | 157.95 | 2.43 | 12.09 | 56.96 | 13.58 | 45.28 | 15.88 | 5.39 |
| Trichlorobenzene 1-3-5 | mg | 13.84 | 8.37 | 12.59 | 71.74 | 425.48 | 6.53 | 32.58 | 153.44 | 36.59 | 121.98 | 42.79 | 14.52 |
| Hexachlorobutadiene | mg | 9.21 | 5.57 | 8.38 | 47.75 | 283.20 | 4.35 | 21.68 | 102.13 | 24.36 | 81.19 | 28.48 | 9.67 |
| Trichlorotoluene 2-4-5 | mg | 23.70 | 14.34 | 21.55 | 122.83 | 728.55 | 11.19 | 55.78 | 262.74 | 62.66 | 208.87 | 73.27 | 24.87 |
| Tetrachlorobenzene 1-2-3-5 | mg | 92.85 | 56.17 | 84.41 | 481.14 | 2,853.71 | 43.83 | 218.49 | 1,029.15 | 245.44 | 818.13 | 286.99 | 97.40 |
| Trichlorotoluene 2-6-A | mg | 21.82 | 13.20 | 19.84 | 113.07 | 670.61 | 10.30 | 51.34 | 241.85 | 57.68 | 192.26 | 67.44 | 22.89 |
| Pentachlorobenzene | mg | 17.71 | 10.71 | 16.10 | 91.74 | 544.15 | 8.36 | 41.66 | 196.24 | 46.80 | 156.00 | 54.73 | 18.57 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | | | | | | |
| Naphthalene | g | 7.30 | 4.40 | 6.60 | 40.70 | 223.30 | 3.40 | 17.10 | 80.50 | 19.20 | 95.00 | 22.50 | 7.60 |
| Acenaphthylene | g | 0.50 | 0.30 | 0.50 | 2.80 | 15.50 | 0.20 | 1.20 | 5.60 | 1.30 | 6.60 | 1.60 | 0.50 |
| Acenaphthene | g | 2.50 | 1.50 | 2.20 | 13.80 | 75.90 | 1.20 | 5.80 | 27.40 | 6.50 | 32.30 | 7.60 | 2.60 |
| Fluorene | g | 3.90 | 2.40 | 3.50 | 21.80 | 119.50 | 1.80 | 9.20 | 43.10 | 10.30 | 50.90 | 12.00 | 4.10 |
| Phenanthrene | g | 32.30 | 19.50 | 29.40 | 181.10 | 993.30 | 15.30 | 76.00 | 358.20 | 85.40 | 422.60 | 99.90 | 33.90 |
| Anthracene | g | 1.30 | 0.80 | 1.20 | 7.60 | 41.40 | 0.60 | 3.20 | 14.90 | 3.60 | 17.60 | 4.20 | 1.40 |
| Fluoranthene | g | 43.80 | 26.50 | 39.80 | 245.30 | 1,344.90 | 20.70 | 103.00 | 485.00 | 115.70 | 572.20 | 135.30 | 45.90 |
| Pyrene | g | 29.50 | 17.80 | 26.80 | 165.10 | 905.40 | 13.90 | 69.30 | 326.50 | 77.90 | 385.20 | 91.10 | 30.90 |
| Benzo (A) Anthracene | g | 9.80 | 5.90 | 8.90 | 54.70 | 299.70 | 4.60 | 22.90 | 108.10 | 25.80 | 127.50 | 30.10 | 10.20 |
| Chrysene | g | 19.40 | 11.70 | 17.60 | 108.50 | 595.10 | 9.10 | 45.60 | 214.60 | 51.20 | 253.20 | 59.80 | 20.30 |
| Benzo (B) Fluoranthene | g | 31.50 | 19.00 | 28.60 | 176.30 | 966.90 | 14.90 | 74.00 | 348.70 | 83.20 | 411.40 | 97.20 | 33.00 |
| Benzo (B-K) Fluoranthene | g | 20.70 | 12.50 | 18.80 | 115.90 | 635.50 | 9.80 | 48.70 | 229.20 | 54.70 | 270.40 | 63.90 | 21.70 |
| Benzo (A) Pyrene | g | 14.30 | 8.60 | 13.00 | 80.00 | 438.60 | 6.70 | 33.60 | 158.20 | 37.70 | 186.60 | 44.10 | 15.00 |
| Indeno (1-2-3 C-D) Pyrene | g | 6.90 | 4.20 | 6.20 | 38.50 | 211.00 | 3.20 | 16.20 | 76.10 | 18.10 | 89.80 | 21.20 | 7.20 |
| Dibenzo (A-H) Anthracene | g | 3.20 | 2.00 | 2.90 | 18.10 | 99.30 | 1.50 | 7.60 | 35.80 | 8.50 | 42.30 | 10.00 | 3.40 |
| Benzo (G-H-I) Perylene | g | 8.20 | 4.90 | 7.40 | 45.70 | 250.50 | 3.80 | 19.20 | 90.30 | 21.50 | 106.60 | 25.20 | 8.50 |

Notes: * regression estimate used, # traditional method used

## TABLE A4.3 PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH

| PARAMETER | UNITS | S1 914 (L1) | S2 912 (L2) | S3 910 (L3) | S4 908 (L4) | S5 906 (L5) | S6 900 (L6) | S7 904 | S8 918 | S9 901 | S10 903 | S11 931,933,935 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | | | | | | | | |
| Chemical Oxygen Demand | T | 45.10 | 92.10 | 38.80 | 113.00 | 54.00 | 204.00 | 126.00 | 104.00 | 122.00 | 192.00 | 96.01 |
| Hardness | T | 12.40 | 25.40 | 10.70 | 31.10 | 14.90 | 56.30 | 34.70 | 28.80 | 33.60 | 52.90 | 26.46 |
| Phenolics (4AAP) | g | 1,010.00 | 2,070.00 | 872.00 | 2,530.00 | 1,210.00 | 4,590.00 | 2,820.00 | 2,340.00 | 2,740.00 | 4,310.00 | 2,154.60 |
| Total suspended solids | T | 7.34 | 15.00 | 6.32 | 18.40 | 8.79 | 33.30 | 20.50 | 17.00 | 19.80 | 31.20 | 15.65 |
| Ammonium | g | 14,200.00 | 29,000.00 | 12,200.00 | 35,500.00 | 17,000.00 | 64,400.00 | 39,600.00 | 32,900.00 | 38,400.00 | 60,500.00 | 30,240.00 |
| Nitrates | kg | 186.00 | 381.00 | 161.00 | 466.00 | 223.00 | 845.00 | 520.00 | 432.00 | 504.00 | 794.00 | 396.90 |
| Nitrite | g | 3,080.00 | 6,290.00 | 2,650.00 | 7,700.00 | 3,690.00 | 13,900.00 | 8,580.00 | 7,120.00 | 8,320.00 | 13,100.00 | 6,558.30 |
| Total Kjeldhal Nitrogen | kg | 146.00 | 298.00 | 125.00 | 364.00 | 174.00 | 660.00 | 406.00 | 337.00 | 394.00 | 620.00 | 309.96 |
| Total Phosphorus | kg | 30.20 | 61.70 | 26.00 | 75.50 | 36.20 | 137.00 | 84.10 | 69.90 | 81.60 | 129.00 | 64.45 |
| **BACTERIOLOGY** | | | | | | | | | | | | |
| E-Coli | TCts | 2,240,000.00* | 4,590,000.00* | 1,930,000.00* | 5,610,000.00* | 2,690,000.00* | 10,200,000.00* | 6,250,000.00* | 5,190,000.00* | 6,060,000.00* | 9,550,000.00* | 4,781,700.00* |
| Fecal Coliform MF | TCts | 3,210,000.25* | 6,569,999.50* | 2,770,000.00* | 8,039,999.50* | 3,850,000.25* | 14,600,000.00* | 8,960,000.00* | 7,440,000.00* | 8,690,000.00* | 13,700,001.00* | 6,860,700.00* |
| **HEAVY METALS** | | | | | | | | | | | | |
| Silver | g | 178.00 | 363.00 | 153.00 | 444.00 | 213.00 | 805.00 | 495.00 | 411.00 | 480.00 | 756.00 | 378.00 |
| Aluminum | kg | 99.50 | 203.00 | 85.70 | 249.00 | 119.00 | 451.00 | 277.00 | 230.00 | 269.00 | 423.00 | 211.68 |
| Arsenic | g | 59.20# | 121.00# | 51.00# | 148.00# | 70.90# | 268.00# | 165.00# | 137.00# | 160.00# | 252.00# | 126.25# |
| Barium | g | 2,780.00 | 5,690.00 | 2,400.00 | 6,960.00 | 3,330.00 | 12,600.00 | 7,750.00 | 6,440.00 | 7,520.00 | 11,800.00 | 5,934.60 |
| Cadmium | g | 178.00 | 363.00 | 153.00 | 444.00 | 213.00 | 805.00 | 495.00 | 411.00 | 480.00 | 756.00 | 378.00 |
| Chromium | g | 829.00 | 1,690.00 | 714.00 | 2,070.00 | 993.00 | 3,750.00 | 2,310.00 | 1,920.00 | 2,240.00 | 3,530.00 | 1,767.15 |
| Copper | g | 7,100.00 | 14,500.00 | 6,120.00 | 17,800.00 | 8,510.00 | 32,200.00 | 19,800.00 | 16,400.00 | 19,200.00 | 30,200.00 | 15,157.80 |
| Iron | kg | 272.00 | 555.00 | 234.00 | 679.00 | 325.00 | 1,230.00 | 757.00 | 629.00 | 734.00 | 1,160.00 | 580.23 |
| Mercury | mg | 3,490.00 | 7,140.00 | 3,010.00 | 8,730.00 | 4,180.00 | 15,800.00 | 9,740.00 | 8,080.00 | 9,440.00 | 14,900.00 | 7,446.60 |
| Manganese | kg | 10.10 | 20.60 | 8.67 | 25.20 | 12.10 | 45.60 | 28.10 | 23.30 | 27.20 | 42.80 | 21.55 |
| Nickel | g | 651.00 | 1,330.00 | 561.00 | 1,630.00 | 780.00 | 2,950.00 | 1,810.00 | 1,510.00 | 1,760.00 | 2,770.00 | 1,389.15 |
| Lead | g | 3,020.00 | 6,170.00 | 2,600.00 | 7,550.00 | 3,620.00 | 13,700.00 | 8,420.00 | 6,990.00 | 8,160.00 | 12,900.00 | 6,444.90 |
| Selenium | g | 59.20# | 121.00# | 51.00# | 148.00# | 70.90# | 268.00# | 165.00# | 137.00# | 160.00# | 252.00# | 126.25# |
| Zinc | kg | 10.70 | 21.80 | 9.18 | 26.60 | 12.80 | 48.30 | 29.70 | 24.70 | 28.80 | 45.40 | 22.68 |

Notes: * regression estimate used,   # traditional method used,   Tct=10^12 counts

# TABLE A4.4    PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH

| PARAMETER | UNITS | CATCHMENT AREA | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 |
| | | 914 (L1) | 912 (L2) | 910 (L3) | 908 (L4) | 906 (L5) | 900 (L6) | 904 | 918 | 901 | 903 | 931,933,935 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | | | | | |
| Alpha-BHC | mg | 115.00 | 235.00 | 98.90 | 287.00 | 138.00 | 520.00 | 320.00 | 266.00 | 310.00 | 489.00 | 245.70 |
| Gamma-BHC | mg | 87.60 | 179.00 | 75.50 | 219.00 | 105.00 | 397.00 | 244.00 | 203.00 | 237.00 | 373.00 | 186.92 |
| 1,3,5-Trichlorobenzene | mg | 122.00 | 249.00 | 105.00 | 305.00 | 146.00 | 552.00 | 340.00 | 282.00 | 330.00 | 519.00 | 260.82 |
| 1,2,4-Trichlorobenzene | mg | 276.00 | 565.00 | 238.00 | 691.00 | 331.00 | 1,250.00 | 771.00 | 640.00 | 747.00 | 1,180.00 | 589.68 |
| 1,2,3-Trichlorobenzene | mg | 124.00* | 254.00* | 107.00* | 311.00* | 149.00* | 563.00* | 346.00* | 288.00* | 336.00* | 529.00* | 264.60* |
| Hexachlorobenzene | mg | 18.87 | 38.56 | 16.25 | 47.23 | 22.60 | 85.47 | 52.58 | 43.66 | 50.99 | 80.31 | 40.16 |
| PP DDE | mg | 9.67 | 19.77 | 8.33 | 24.21 | 11.58 | 43.82 | 26.96 | 22.38 | 26.14 | 41.17 | 20.58 |
| Alpha Chlordane | mg | 40.03 | 81.82 | 34.49 | 100.21 | 47.94 | 181.36 | 111.57 | 92.64 | 108.19 | 170.40 | 85.20 |
| Gamma Chlordane | mg | 35.39 | 72.33 | 30.49 | 88.59 | 42.38 | 160.32 | 98.63 | 81.89 | 95.64 | 150.63 | 75.32 |
| OP DDT | mg | 18.70 | 38.23 | 16.11 | 46.83 | 22.40 | 84.74 | 52.13 | 43.29 | 50.55 | 79.62 | 39.81 |
| PP DDT | mg | 64.74 | 132.32 | 55.77 | 162.07 | 77.53 | 293.30 | 180.44 | 149.82 | 174.97 | 275.58 | 137.79 |
| Dieldrin | mg | 47.11 | 96.29 | 40.58 | 117.94 | 56.42 | 213.43 | 131.30 | 109.02 | 127.33 | 200.54 | 100.27 |
| Hexachloroethane | mg | 10.64 | 21.74 | 9.16 | 26.63 | 12.74 | 48.19 | 29.65 | 24.62 | 28.75 | 45.28 | 22.64 |
| Trichlorobenzene 1-3-5 | mg | 28.66 | 58.57 | 24.69 | 71.74 | 34.32 | 129.82 | 79.87 | 66.31 | 77.45 | 121.98 | 60.99 |
| Hexachlorobutadiene | mg | 19.07 | 38.98 | 16.43 | 47.75 | 22.84 | 86.41 | 53.16 | 44.14 | 51.55 | 81.19 | 40.59 |
| Trichlorotoluene 2-4-5 | mg | 49.07 | 100.29 | 42.27 | 122.83 | 58.76 | 222.29 | 136.76 | 113.55 | 132.61 | 208.87 | 104.43 |
| Tetrachlorobenzene 1-2-3-5 | mg | 192.19 | 392.83 | 165.57 | 481.14 | 230.18 | 870.72 | 535.68 | 444.78 | 519.45 | 818.13 | 409.06 |
| Trichlorotoluene 2-6-A | mg | 45.17 | 92.31 | 38.91 | 113.07 | 54.09 | 204.62 | 125.88 | 104.52 | 122.07 | 192.26 | 96.13 |
| Pentachlorobenzene | mg | 36.65 | 74.91 | 31.57 | 91.74 | 43.89 | 166.03 | 102.15 | 84.81 | 99.05 | 156.00 | 78.00 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | | | | | |
| Naphthalene | g | 15.00 | 30.70 | 13.00 | 37.60 | 18.00 | 68.10 | 41.90 | 34.80 | 40.60 | 64.00 | 32.10 |
| Acenaphthylene | g | 1.00 | 2.10 | 0.90 | 2.60 | 1.20 | 4.70 | 2.90 | 2.40 | 2.80 | 4.40 | 2.30 |
| Acenaphthene | g | 5.10 | 10.40 | 4.40 | 12.80 | 6.10 | 23.10 | 14.20 | 11.80 | 13.80 | 21.70 | 11.00 |
| Fluorene | g | 8.10 | 16.50 | 6.90 | 20.20 | 9.60 | 36.50 | 22.40 | 18.60 | 21.80 | 34.30 | 17.20 |
| Phenanthrene | g | 66.90 | 136.70 | 57.60 | 167.50 | 80.10 | 303.10 | 186.50 | 154.80 | 180.80 | 284.80 | 142.70 |
| Anthracene | g | 2.80 | 5.70 | 2.40 | 7.00 | 3.30 | 12.60 | 7.80 | 6.50 | 7.50 | 11.90 | 5.90 |
| Fluoranthene | g | 90.60 | 185.10 | 78.00 | 226.70 | 108.50 | 410.30 | 252.50 | 209.60 | 244.80 | 385.60 | 193.20 |
| Pyrene | g | 61.00 | 124.60 | 52.50 | 152.60 | 73.00 | 276.20 | 170.00 | 141.10 | 164.80 | 259.60 | 130.00 |
| Benzo (A) Anthracene | g | 20.20 | 41.30 | 17.40 | 50.50 | 24.20 | 91.50 | 56.30 | 46.70 | 54.60 | 85.90 | 43.10 |
| Chrysene | g | 40.10 | 81.90 | 34.50 | 100.30 | 48.00 | 181.60 | 111.70 | 92.70 | 108.30 | 170.60 | 85.40 |
| Benzo (B) Fluoranthene | g | 65.10 | 133.10 | 56.10 | 163.00 | 78.00 | 295.00 | 181.50 | 150.70 | 176.00 | 277.20 | 138.90 |
| Benzo (B-K) Fluoranthene | g | 42.80 | 87.50 | 36.90 | 107.10 | 51.30 | 193.90 | 119.30 | 99.10 | 115.70 | 182.20 | 91.30 |
| Benzo (A) Pyrene | g | 29.50 | 60.40 | 25.40 | 74.00 | 35.40 | 133.80 | 82.30 | 68.40 | 79.80 | 125.70 | 62.90 |
| Indeno (1-2-3 C-D) Pyren | eg | 14.20 | 29.00 | 12.20 | 35.60 | 17.00 | 64.40 | 39.60 | 32.90 | 38.40 | 60.50 | 30.20 |
| Dibenzo (A-H) Anthracene | g | 6.70 | 13.70 | 5.80 | 16.70 | 8.00 | 30.30 | 18.60 | 15.50 | 18.10 | 28.50 | 14.20 |
| Benzo (G-H-I) Perylene | g | 16.90 | 34.50 | 14.50 | 42.20 | 20.20 | 76.40 | 47.00 | 39.00 | 45.60 | 71.80 | 35.90 |

Notes:  * regression estimate used,   # traditional method used

## TABLE A4.5 PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH

| PARAMETER | UNITS | CATCHMENT AREA | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | S12 | S13 | S14 | S15 | S16 | S17 | S18 |
| | | 925 | 913 | 911 | 909,915 | 927 | | 919 |
| **GENERAL CHEMISTRY** | | | | | | | | |
| Chemical Oxygen Demand | T | 137.00 | 80.70 | 57.30 | 54.60 | 76.10 | 75.10 | 236.57 |
| Hardness | T | 38.00 | 22.30 | 15.80 | 15.10 | 21.00 | 20.70 | 65.12 |
| Phenolics (4AAP) | g | 3,099.00 | 1,810.00 | 1,290.00 | 1,230.00 | 1,710.00 | 1,687.00 | 5,314.05 |
| Total suspended solids | T | 22.46 | 13.10 | 9.34 | 8.90 | 12.40 | 12.20 | 38.43 |
| Ammonium | g | 43,472.00 | 25,400.00 | 18,100.00 | 17,200.00 | 24,000.00 | 23,700.00 | 74,655.00 |
| Nitrates | kg | 570.00 | 334.00 | 237.00 | 226.00 | 315.00 | 311.00 | 979.65 |
| Nitrite | g | 9,412.00 | 5,510.00 | 3,920.00 | 3,730.00 | 5,200.00 | 5,132.00 | 16,165.80 |
| Total Kjeldhal Nitrogen | kg | 445.00 | 261.00 | 185.00 | 177.00 | 246.00 | 242.00 | 762.30 |
| Total Phosphorus | kg | 92.00 | 54.10 | 38.40 | 36.60 | 51.00 | 50.00 | 157.50 |
| **BACTERIOLOGY** | | | | | | | | |
| E-Coli | TCts | 6,850,000.00* | 4,019,999.75* | 2,850,000.00* | 2,720,000.00* | 3,790,000.00* | 3,740,000.00* | 11,781,000.00* |
| Fecal Coliform MF | TCts | 9,820,000.00* | 5,759,999.50* | 4,089,999.75* | 3,899,999.75* | 5,430,000.00* | 5,350,000.00* | 16,852,599.00* |
| **HEAVY METALS** | | | | | | | | |
| Silver | g | 542.00 | 318.00 | 226.00 | 215.00 | 300.00 | 296.00 | 932.40 |
| Aluminum | kg | 303.00 | 178.00 | 127.00 | 121.00 | 168.00 | 165.00 | 519.75 |
| Arsenic | g | 181.00# | 106.00# | 75.30# | 71.80# | 100.00# | 98.70# | 310.91 |
| Barium | g | 8,507.00 | 4,980.00 | 3,540.00 | 3,370.00 | 4,700.00 | 4,639.00 | 14,612.85 |
| Cadmium | g | 543.00 | 318.00 | 226.00 | 215.00 | 300.00 | 296.00 | 932.40 |
| Chromium | g | 2,537.00 | 1,480.00 | 1,050.00 | 1,010.00 | 1,400.00 | 1,381.00 | 4,350.15 |
| Copper | g | 21,736.00 | 12,700.00 | 9,040.00 | 8,620.00 | 12,000.00 | 11,844.00 | 37,308.60 |
| Iron | kg | 831.00 | 487.00 | 346.00 | 330.00 | 459.00 | 453.00 | 1,426.95 |
| Mercury | mg | 10,712.00 | 6,250.00 | 4,440.00 | 4,240.00 | 5,900.00 | 5,823.00 | 18,342.45 |
| Manganese | kg | 30.80 | 18.00 | 12.80 | 12.20 | 17.00 | 16.80 | 52.92 |
| Nickel | g | 1,986.00 | 1,170.00 | 828.00 | 790.00 | 1,100.00 | 1,085.00 | 3,417.75 |
| Lead | g | 9,224.00 | 5,410.00 | 3,840.00 | 3,660.00 | 5,100.00 | 5,033.00 | 15,853.95 |
| Selenium | g | 181.00 | 106.00# | 75.30# | 71.80# | 100.00# | 98.70# | 310.91 |
| Zinc | kg | 32.60 | 19.10 | 13.60 | 12.90 | 18.00 | 17.77 | 55.98 |

Notes: * regression estimate used, # traditional method used, Tct=10^12 counts

## TABLE A4.6    PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH

| PARAMETER | UNITS | CATCHMENT AREA | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | S12 | S13 | S14 | S15 | S16 | S17 | S18 |
| | | 925 | 913 | 911 | 909,915 | 927 | | 919 |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | |
| Alpha-BHC | mg | 351.00 | 206.00 | 146.00 | 139.00 | 194.00 | 191.48 | 603.16 |
| Gamma-BHC | mg | 268.00 | 157.00 | 111.00 | 106.00 | 148.00 | 146.08 | 460.15 |
| 1,3,5-Trichlorobenzene | mg | 372.00 | 218.00 | 155.00 | 148.00 | 206.00 | 203.32 | 640.46 |
| 1,2,4-Trichlorobenzene | mg | 845.00 | 495.00 | 352.00 | 335.00 | 467.00 | 461.00 | 1,452.15 |
| 1,2,3-Trichlorobenzene | mg | 379.00 | 223.00* | 158.00* | 151.00* | 210.00* | 207.00* | 652.05 |
| Hexachlorobenzene | mg | 57.68 | 33.78 | 24.00 | 22.88 | 31.87 | 31.45 | 99.11 |
| PP DDE | mg | 29.57 | 17.32 | 12.30 | 11.73 | 16.34 | 16.12 | 50.81 |
| Alpha Chlordane | mg | 122.39 | 71.68 | 50.92 | 48.55 | 67.62 | 66.74 | 210.30 |
| Gamma Chlordane | mg | 108.19 | 63.36 | 45.01 | 42.92 | 59.77 | 59.00 | 185.90 |
| OP DDT | mg | 57.19 | 33.49 | 23.79 | 22.69 | 31.60 | 31.19 | 98.26 |
| PP DDT | mg | 197.94 | 115.92 | 82.35 | 78.52 | 109.36 | 107.94 | 340.10 |
| Dieldrin | mg | 144.04 | 84.35 | 59.92 | 57.14 | 79.58 | 78.54 | 247.49 |
| Hexachloroethane | mg | 32.52 | 19.05 | 13.53 | 12.90 | 17.97 | 17.74 | 55.88 |
| Trichlorobenzene 1-3-5 | mg | 87.61 | 51.31 | 36.45 | 34.75 | 48.40 | 47.78 | 150.54 |
| Hexachlorobutadiene | mg | 58.31 | 34.15 | 24.26 | 23.13 | 32.22 | 31.80 | 100.20 |
| Trichlorotoluene 2-4-5 | mg | 150.02 | 87.86 | 62.41 | 59.51 | 82.88 | 81.81 | 257.77 |
| Tetrachlorobenzene 1-2-3-5 | mg | 587.62 | 344.13 | 244.46 | 233.10 | 324.65 | 320.43 | 1,009.67 |
| Trichlorotoluene 2-6-A | mg | 138.09 | 80.87 | 57.45 | 54.78 | 76.29 | 75.30 | 237.27 |
| Pentachlorobenzene | mg | 112.05 | 65.62 | 46.62 | 44.45 | 61.91 | 61.10 | 192.53 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | |
| Naphthalene | g | 46.00 | 26.90 | 19.10 | 18.20 | 25.40 | 25.10 | 79.07 |
| Acenaphthylene | g | 3.20 | 1.90 | 1.30 | 1.30 | 1.80 | 1.70 | 5.35 |
| Acenaphthene | g | 15.60 | 9.10 | 6.50 | 6.20 | 8.60 | 8.50 | 26.78 |
| Fluorene | g | 24.60 | 14.40 | 10.20 | 9.80 | 13.60 | 13.40 | 42.21 |
| Phenanthrene | g | 204.50 | 119.80 | 85.10 | 81.10 | 113.00 | 111.50 | 351.22 |
| Anthracene | g | 8.50 | 5.00 | 3.50 | 3.40 | 4.70 | 4.60 | 14.49 |
| Fluoranthene | g | 276.90 | 162.20 | 115.20 | 109.90 | 153.00 | 151.00 | 475.65 |
| Pyrene | g | 186.40 | 109.20 | 77.60 | 74.00 | 103.00 | 101.70 | 320.36 |
| Benzo (A) Anthracene | g | 61.70 | 36.10 | 25.70 | 24.50 | 34.10 | 33.70 | 106.16 |
| Chrysene | g | 122.50 | 71.80 | 51.00 | 48.60 | 67.70 | 66.80 | 210.42 |
| Benzo (B) Fluoranthene | g | 199.10 | 116.60 | 82.80 | 79.00 | 110.00 | 108.60 | 342.09 |
| Benzo (B-K) Fluoranthene | g | 130.90 | 76.60 | 54.40 | 51.90 | 72.30 | 71.40 | 224.91 |
| Benzo (A) Pyrene | g | 90.30 | 52.90 | 37.60 | 35.80 | 49.90 | 49.30 | 155.30 |
| Indeno (1-2-3 C-D) Pyrene | g | 43.40 | 25.40 | 18.10 | 17.20 | 24.00 | 23.70 | 74.66 |
| Dibenzo (A-H) Anthracene | g | 20.50 | 12.00 | 8.50 | 8.10 | 11.30 | 11.20 | 35.28 |
| Benzo (G-H-I) Perylene | g | 51.60 | 30.20 | 21.50 | 20.50 | 28.50 | 28.10 | 88.52 |

Notes: * regression estimate used,  # traditional method used

**TABLE A4.7    PREDICTIVE WINTER/SPRING LOADING ESTIMATES FOR ETOBICOKE**

| PARAMETER | UNITS | E1 L102 | E2 L103 | E3 L104,L105 | E4 L201,L202 L203A | E5 L203B,L204 L205 | E6 L301 | E7 L302,L303,L304 L305,L306,L307 | E8 L308,L309 | E9 L401,L402 L403 | E10 L403C | E11 L404 | E12 L405,L406, L407,L408 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GENERAL CHEMISTRY** | | | | | | | | | | | | | |
| Chemical Oxygen Demand | T | 43.50 | 26.30 | 39.60 | 244.00 | 1,308.00 | 20.70 | 102.00 | 482.00 | 115.00 | 569.00 | 135.00 | 45.70 |
| Hardness | T | 12.00 | 7.27 | 10.90 | 67.30 | 361.00 | 5.70 | 28.30 | 133.00 | 31.80 | 157.00 | 37.20 | 12.60 |
| Phenolics (4AAP) | g | 978.00 | 592.00 | 889.00 | 5,480.00 | 29,400.00 | 464.00 | 2,300.00 | 10,800.00 | 2,590.00 | 12,800.00 | 3,030.00 | 1,027.00 |
| Total suspended solids | T | 7.09 | 4.29 | 6.45 | 39.80 | 213.00 | 3.42 | 16.70 | 78.60 | 18.70 | 92.70 | 21.90 | 7.40 |
| Ammonium | kg | 13.70 | 8.30 | 12.50 | 76.90 | 412.00 | 6.50 | 32.30 | 152.00 | 36.30 | 179.00 | 42.50 | 14.50 |
| Nitrates | kg | 180.00 | 109.00 | 164.00 | 1,010.00 | 5,415.00 | 85.80 | 424.00 | 2,000.00 | 476.00 | 2,350.00 | 558.00 | 189.70 |
| Nitrite | kg | 2.97 | 1.80 | 2.70 | 16.70 | 89.40 | 1.40 | 7.00 | 33.00 | 7.86 | 38.90 | 9.20 | 3.10 |
| Total Kjeldhal Nitrogen | kg | 141.00 | 85.10 | 128.00 | 789.00 | 4,230.00 | 66.80 | 331.00 | 1,560.00 | 372.00 | 1,840.00 | 435.00 | 148.00 |
| Total Phosphorus | kg | 29.20 | 17.60 | 26.50 | 164.00 | 877.00 | 13.80 | 68.60 | 323.00 | 77.10 | 381.00 | 90.30 | 30.70 |
| **BACTERIOLOGY** | | | | | | | | | | | | | |
| E-Coli | TCts | 2,170,000.00* | 1,310,000.00* | 1,970,000.00* | 12,200,000.00* | 65,100,000.00* | 1,030,000.00* | 5,100,000.00* | 24,000,000.00 | 5,730,000.00* | 28,300,000.00* | 6,710,000.00* | 2,280,000.00 |
| Fecal Coliform MF | TCts | 3,110,000.00* | 1,880,000.00* | 2,820,000.00* | 17,400,000.00* | 93,300,000.00* | 1,474,000.00* | 7,310,000.00* | 34,400,000.00 | 8,210,000.00* | 40,600,000.00* | 9,610,000.00* | 3,270,000.00 |
| **HEAVY METALS** | | | | | | | | | | | | | |
| Silver | g | 172.00 | 104.00 | 156.00 | 962.00 | 5,160.00 | 81.00 | 404.00 | 1,900.00 | 454.00 | 2,240.00 | 531.00 | 180.00 |
| Aluminum | kg | 96.10 | 58.10 | 87.40 | 539.00 | 2,895.00 | 46.00 | 226.00 | 1,070.00 | 254.00 | 1,260.00 | 297.00 | 101.00 |
| Arsenic | g | 57.20# | 34.60# | 52.00# | 321.00# | 1,725.00# | 27.10# | 135.00# | 634.00 | 151.00# | 747.00# | 177.00# | 60.20# |
| Barium | kg | 2.69 | 1.63 | 2.44 | 15.10 | 80.90 | 1.30 | 6.33 | 29.80 | 7.11 | 35.10 | 8.32 | 2.80 |
| Cadmium | g | 172.00 | 104.00 | 156.00 | 962.00 | 5,160.00 | 81.10 | 404.00 | 1,900.00 | 454.00 | 2,240.00 | 531.00 | 180.00 |
| Chromium | g | 801.00 | 484.00 | 728.00 | 4,490.00 | 24,000.00 | 379.00 | 1,880.00 | 8,880.00 | 2,120.00 | 10,500.00 | 2,480.00 | 843.00 |
| Copper | kg | 6.86 | 4.15 | 6.24 | 38.50 | 207.00 | 3.30 | 16.20 | 76.10 | 18.10 | 89.70 | 21.20 | 7.20 |
| Iron | kg | 263.00 | 159.00 | 239.00 | 1,470.00 | 7,890.00 | 124.80 | 618.00 | 2,910.00 | 694.00 | 3,430.00 | 812.00 | 276.00 |
| Mercury | g | 3.37 | 2.04 | 3.07 | 18.90 | 101.00 | 1.60 | 7.94 | 37.40 | 8.92 | 44.10 | 10.40 | 3.50 |
| Manganese | kg | 9.72 | 5.88 | 8.84 | 54.50 | 293.00 | 4.60 | 22.90 | 108.00 | 25.70 | 127.00 | 30.10 | 10.20 |
| Nickel | g | 629.00 | 381.00 | 572.00 | 3,530.00 | 18,900.00 | 299.00 | 1,480.00 | 6,970.00 | 1,660.00 | 8,220.00 | 1,950.00 | 663.00 |
| Lead | kg | 2.92 | 1.76 | 2.65 | 16.40 | 87.80 | 1.40 | 6.86 | 32.30 | 7.71 | 38.10 | 9.03 | 3.10 |
| Selenium | g | 57.20# | 34.60# | 52.00# | 321.00# | 1,725.00# | 29.50# | 135.00# | 634.00 | 151.00# | 747.00# | 177.00# | 60.20# |
| Zinc | kg | 10.30 | 6.23 | 9.36 | 57.70 | 309.00 | 4.90 | 24.20 | 114.00 | 27.20 | 135.00 | 31.90 | 10.80 |

Notes: * regression estimate used,   # traditional method used, Tct=10^12 counts

# TABLE A4.8     PREDICTIVE WINTER/SPRING LOADING ESTIMATES FOR ETOBICOKE

| PARAMETER | UNITS | E1 L102 | E2 L103 | E3 L104,L105 | E4 L201,L202 L203A | E5 L203B,L204 L205 | E6 L301 | E7 L302,L303,L304 L305,L306,L307 | E8 L308,L309 | E9 L401,L402 L403 | E10 L403C | E11 L404 | E12 L405,L406, L407,L408 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | | | | | | |
| Alpha-BHC | mg | 111.00 | 67.10 | 101.00 | 622.00 | 3,330.00 | 52.70 | 261.00 | 1,230.00 | 293.00 | 1,450.00 | 343.00 | 116.00 |
| Gamma-BHC | mg | 84.70 | 51.20 | 77.00 | 474.00 | 2,550.00 | 40.20 | 199.00 | 938.00 | 224.00 | 1,110.00 | 262.00 | 89.00 |
| 1,3,5-Trichlorobenzene | mg | 118.00 | 71.30 | 107.00 | 660.00 | 3,540.00 | 55.90 | 277.00 | 1,310.00 | 311.00 | 1,540.00 | 365.00 | 124.00 |
| 1,2,4-Trichlorobenzene | mg | 267.00 | 162.00 | 243.00 | 1,500.00 | 8,025.00 | 127.00 | 629.00 | 2,960.00 | 706.00 | 3,490.00 | 827.00 | 281.00 |
| 1,2,3-Trichlorobenzene | mg | 120.00* | 72.70* | 109.00* | 673.00* | 3,615.00* | 57.00* | 283.00* | 1,330.00* | 318.00* | 1,570.00* | 372.00* | 126.00* |
| Hexachlorobenzene | mg | 18.23 | 11.03 | 16.57 | 94.46 | 560.26 | 8.60 | 42.90 | 202.05 | 48.19 | 160.62 | 56.34 | 19.12 |
| PP DDE | mg | 9.34 | 5.65 | 8.50 | 48.42 | 287.21 | 4.41 | 21.99 | 103.58 | 24.70 | 82.34 | 28.88 | 9.80 |
| Alpha Chlordane | mg | 38.68 | 23.40 | 35.16 | 200.43 | 1,188.77 | 18.26 | 91.02 | 428.71 | 102.24 | 340.81 | 119.55 | 40.57 |
| Gamma Chlordane | mg | 34.19 | 20.68 | 31.08 | 177.17 | 1,050.84 | 16.14 | 80.46 | 378.97 | 90.38 | 301.27 | 105.68 | 35.86 |
| OP DDT | mg | 18.07 | 10.93 | 16.43 | 93.65 | 555.46 | 8.53 | 42.53 | 200.32 | 47.77 | 159.25 | 55.86 | 18.96 |
| PP DDT | mg | 62.55 | 37.84 | 56.87 | 324.14 | 1,922.51 | 29.53 | 147.20 | 693.33 | 165.35 | 551.16 | 193.34 | 65.61 |
| Dieldrin | mg | 45.52 | 27.53 | 41.38 | 235.87 | 1,398.99 | 21.49 | 107.11 | 504.53 | 120.32 | 401.07 | 140.69 | 47.75 |
| Hexachloroethane | mg | 10.28 | 6.22 | 9.34 | 53.26 | 315.89 | 4.85 | 24.19 | 113.92 | 27.17 | 90.56 | 31.77 | 10.78 |
| Trichlorobenzene 1-3-5 | mg | 27.69 | 16.75 | 25.17 | 143.47 | 850.96 | 13.07 | 65.15 | 306.89 | 73.19 | 243.96 | 85.58 | 29.04 |
| Hexachlorobutadiene | mg | 18.43 | 11.15 | 16.75 | 95.49 | 566.39 | 8.70 | 43.37 | 204.26 | 48.71 | 162.38 | 56.96 | 19.33 |
| Trichlorotoluene 2-4-5 | mg | 47.41 | 28.68 | 43.10 | 245.67 | 1,457.10 | 22.38 | 111.56 | 525.48 | 125.32 | 417.73 | 146.54 | 49.73 |
| Tetrachlorobenzene 1-2-3-5 | mg | 185.70 | 112.33 | 168.82 | 962.27 | 5,707.41 | 87.66 | 436.98 | 2,058.30 | 490.88 | 1,636.25 | 573.99 | 194.79 |
| Trichlorotoluene 2-6-A | mg | 43.64 | 26.40 | 39.67 | 226.13 | 1,341.22 | 20.60 | 102.69 | 483.70 | 115.35 | 384.51 | 134.89 | 45.78 |
| Pentachlorobenzene | mg | 35.41 | 21.42 | 32.19 | 183.49 | 1,088.31 | 16.71 | 83.33 | 392.48 | 93.60 | 312.01 | 109.45 | 37.14 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | | | | | | |
| Naphthalene | g | 14.50 | 8.80 | 13.20 | 81.40 | 446.50 | 6.90 | 34.20 | 161.00 | 38.40 | 190.00 | 44.90 | 15.20 |
| Acenaphthylene | g | 1.00 | 0.60 | 0.90 | 5.60 | 30.90 | 0.50 | 2.40 | 11.20 | 2.70 | 13.20 | 3.10 | 1.10 |
| Acenaphthene | g | 4.90 | 3.00 | 4.50 | 27.70 | 151.70 | 2.30 | 11.60 | 54.70 | 13.00 | 64.60 | 15.30 | 5.20 |
| Fluorene | g | 7.80 | 4.70 | 7.10 | 43.60 | 239.10 | 3.70 | 18.30 | 86.20 | 20.60 | 101.70 | 24.00 | 8.20 |
| Phenanthrene | g | 64.60 | 39.10 | 58.80 | 362.30 | 1,986.50 | 30.50 | 152.10 | 716.40 | 170.90 | 845.20 | 199.80 | 67.80 |
| Anthracene | g | 2.70 | 1.60 | 2.40 | 15.10 | 82.80 | 1.30 | 6.30 | 29.90 | 7.10 | 35.20 | 8.30 | 2.80 |
| Fluoranthene | g | 87.50 | 52.90 | 79.60 | 490.50 | 2,689.70 | 41.30 | 205.90 | 970.00 | 231.30 | 1,144.40 | 270.50 | 91.80 |
| Pyrene | g | 58.90 | 35.60 | 53.60 | 330.20 | 1,810.70 | 27.80 | 138.60 | 653.00 | 155.70 | 770.40 | 182.10 | 61.80 |
| Benzo (A) Anthracene | g | 19.50 | 11.80 | 17.70 | 109.30 | 599.50 | 9.20 | 45.90 | 216.20 | 51.60 | 255.10 | 60.30 | 20.50 |
| Chrysene | g | 38.70 | 23.40 | 35.20 | 217.00 | 1,190.20 | 18.30 | 91.10 | 429.20 | 102.40 | 506.40 | 119.70 | 40.60 |
| Benzo (B) Fluoranthene | g | 62.90 | 38.10 | 57.20 | 352.70 | 1,933.80 | 29.70 | 148.10 | 697.40 | 166.30 | 822.80 | 194.50 | 66.00 |
| Benzo (B-K) Fluoranthene | g | 41.40 | 25.00 | 37.60 | 231.80 | 1,271.00 | 19.50 | 97.30 | 458.40 | 109.30 | 540.80 | 127.80 | 43.40 |
| Benzo (A) Pyrene | g | 28.50 | 17.30 | 25.90 | 160.00 | 877.20 | 13.50 | 67.20 | 316.40 | 75.40 | 373.30 | 88.20 | 29.90 |
| Indeno (1-2-3 C-D) Pyrene | g | 13.70 | 8.30 | 12.50 | 76.90 | 421.90 | 6.50 | 32.30 | 152.20 | 36.30 | 179.50 | 42.40 | 14.40 |
| Dibenzo (A-H) Anthracene | g | 6.50 | 3.90 | 5.90 | 36.20 | 198.70 | 3.10 | 15.20 | 71.60 | 17.10 | 84.50 | 20.00 | 6.80 |
| Benzo (G-H-I) Perylene | g | 16.30 | 9.90 | 14.80 | 91.40 | 501.00 | 7.70 | 38.40 | 180.70 | 43.10 | 213.20 | 50.40 | 17.10 |

Notes: * regression estimate used, # traditional method used

## TABLE A4.9 PREDICTIVE WINTER/SPRING LOADING ESTIMATES FOR SCARBOROUGH

| PARAMETER | UNITS | CATCHMENT AREA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 914 (L1) | S2 912 (L2) | S3 910 (L3) | S4 908 (L4) | S5 906 (L5) | S6 900 (L6) | S7 904 | S8 918 | S9 901 | S10 903 | S11 931,933,935 |
| **GENERAL CHEMISTRY** | | | | | | | | | | | | |
| Chemical Oxygen Demand | T | 90.10 | 184.00 | 77.60 | 225.00 | 108.00 | 408.00 | 251.00 | 209.00 | 244.00 | 384.00 | 192.78 |
| Hardness | T | 24.90 | 50.80 | 21.40 | 62.20 | 29.80 | 113.00 | 69.30 | 57.50 | 67.20 | 106.00 | 53.11 |
| Phenolics (4AAP) | g | 2,020.00 | 4,140.00 | 1,740.00 | 5,060.00 | 2,420.00 | 9,170.00 | 5,640.00 | 4,690.00 | 5,470.00 | 8,620.00 | 4,309.20 |
| Total suspended solids | T | 14.70 | 30.00 | 12.60 | 36.70 | 17.60 | 66.50 | 40.90 | 34.00 | 39.70 | 62.50 | 31.37 |
| Ammonium | kg | 28.40 | 58.10 | 24.50 | 71.00 | 34.00 | 129.00 | 79.20 | 65.80 | 76.80 | 121.00 | 60.67 |
| Nitrates | kg | 373.00 | 762.00 | 321.00 | 932.00 | 447.00 | 1,690.00 | 1,040.00 | 863.00 | 1,010.00 | 1,590.00 | 795.69 |
| Nitrite | kg | 6.16 | 12.60 | 5.30 | 15.40 | 7.37 | 27.90 | 17.20 | 14.20 | 16.60 | 26.20 | 13.14 |
| Total Kjeldahl Nitrogen | kg | 291.00 | 595.00 | 251.00 | 728.00 | 349.00 | 1,320.00 | 812.00 | 674.00 | 787.00 | 1,240.00 | 621.81 |
| Total Phosphorus | kg | 60.40 | 123.00 | 52.00 | 151.00 | 72.30 | 274.00 | 168.00 | 140.00 | 163.00 | 257.00 | 128.71 |
| **BACTERIOLOGY** | | | | | | | | | | | | |
| E-Coli | TCts | 4,490,000.00* | 9,170,000.00* | 3,870,000.00* | 11,200,000.00* | 5,370,000.00* | 20,300,000.00* | 12,500,000.00* | 10,400,000.00* | 12,099,999.00* | 19,100,000.00* | 9,563,400.00 |
| Fecal Coliform MF | TCts | 6,430,000.00* | 13,100,000.00* | 5,540,000.00* | 16,100,000.00* | 7,700,000.50* | 29,100,000.00* | 17,900,000.00* | 14,900,000.00* | 17,400,000.00* | 27,400,002.00* | 13,702,500.00 |
| **HEAVY METALS** | | | | | | | | | | | | |
| Silver | g | 355.00 | 726.00 | 306.00 | 888.00 | 425.00 | 1,610.00 | 990.00 | 822.00 | 960.00 | 1,510.00 | 757.89 |
| Aluminum | kg | 199.00 | 407.00 | 171.00 | 497.00 | 238.00 | 901.00 | 554.00 | 460.00 | 538.00 | 847.00 | 423.36 |
| Arsenic | g | 118.00# | 242.00# | 102.00# | 296.00# | 142.00# | 536.00# | 330.00# | 274.00# | 320.00# | 504.00# | 253.26 |
| Barium | kg | 5.56 | 11.40 | 4.79 | 13.90 | 6.66 | 25.20 | 15.50 | 12.90 | 15.00 | 23.70 | 11.87 |
| Cadmium | g | 355.00 | 726.00 | 306.00 | 888.00 | 425.00 | 1,610.00 | 990.00 | 822.00 | 960.00 | 1,510.00 | 757.89 |
| Chromium | g | 1,660.00 | 3,390.00 | 1,430.00 | 4,140.00 | 1,990.00 | 7,510.00 | 4,620.00 | 3,840.00 | 4,480.00 | 7,060.00 | 3,534.30 |
| Copper | kg | 14.20 | 29.00 | 12.20 | 35.50 | 17.00 | 64.40 | 39.60 | 32.90 | 38.40 | 60.50 | 30.24 |
| Iron | kg | 543.00 | 1,110.00 | 468.00 | 1,360.00 | 651.00 | 2,460.00 | 1,510.00 | 1,260.00 | 1,470.00 | 2,310.00 | 1,158.57 |
| Mercury | g | 6.99 | 14.30 | 6.02 | 17.50 | 8.37 | 31.60 | 19.50 | 16.20 | 18.90 | 29.70 | ·14.89 |
| Manganese | kg | 20.10 | 41.10 | 17.30 | 50.30 | 24.10 | 91.20 | 56.10 | 46.60 | 54.40 | 85.70 | 42.90 |
| Nickel | g | 1,300.00 | 2,660.00 | 1,120.00 | 3,260.00 | 1,560.00 | 5,900.00 | 3,630.00 | 3,010.00 | 3,520.00 | 5,540.00 | 2,778.30 |
| Lead | kg | 6.04 | 12.30 | 5.20 | 15.10 | 7.23 | 27.40 | 16.80 | 14.00 | 16.30 | 25.70 | 12.87 |
| Selenium | g | 118.00# | 242.00# | 102.00# | 296.00# | 142.00# | 536.00# | 330.00# | 274.00# | 320.00# | 504.00# | 253.26 |
| Zinc | kg | 21.30 | 43.60 | 18.40 | 53.30 | 25.50 | 96.60 | 59.40 | 49.30 | 57.60 | 90.70 | 45.36 |

Notes: * regression estimate used, # traditional method used, Tct=10^12 counts

**TABLE A4.10          PREDICTIVE WINTER/SPRING LOADING ESTIMATES FOR SCARBOROUGH**

| PARAMETER | UNITS | S1 914 (L1) | S2 912 (L2) | S3 910 (L3) | S4 908 (L4) | S5 906 (L5) | S6 900 (L6) | S7 904 | S8 918 | S9 901 | S10 903 | S11 931,933,935 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CATCHMENT AREA** | | | | | | | | | | | | |
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | | | | | |
| Alpha-BHC | mg | 230.00 | 469.00 | 198.00 | 574.00 | 275.00 | 1,040.00 | 640.00 | 532.00 | 621.00 | 978.00 | 489.51 |
| Gamma-BHC | mg | 175.00 | 358.00 | 151.00 | 438.00 | 210.00 | 794.00 | 488.00 | 406.00 | 474.00 | 746.00 | 374.22 |
| 1,3,5-Trichlorobenzene | mg | 244.00 | 499.00 | 210.00 | 610.00 | 292.00 | 1,100.00 | 680.00 | 564.00 | 659.00 | 1,040.00 | 519.75 |
| 1,2,4-Trichlorobenzene | mg | 553.00 | 1,130.00 | 476.00 | 1,380.00 | 662.00 | 2,500.00 | 1,540.00 | 1,280.00 | 1,490.00 | 2,350.00 | 1,179.36 |
| 1,2,3-Trichlorobenzene | mg | 249.00* | 508.00* | 214.00* | 622.00* | 298.00* | 1,130.00* | 693.00* | 575.00* | 672.00* | 1,060.00* | 531.09 |
| Hexachlorobenzene | mg | 37.73 | 77.12 | 32.51 | 94.46 | 45.19 | 170.95 | 105.17 | 87.32 | 101.98 | 160.62 | 80.31 |
| PP DDE | mg | 19.34 | 39.54 | 16.66 | 48.42 | 23.17 | 87.63 | 53.91 | 44.76 | 52.28 | 82.34 | 41.17 |
| Alpha Chlordane | mg | 80.06 | 163.64 | 68.97 | 200.43 | 95.89 | 362.72 | 223.15 | 185.28 | 216.39 | 340.81 | 170.40 |
| Gamma Chlordane | mg | 70.77 | 144.66 | 60.97 | 177.17 | 84.76 | 320.63 | 197.26 | 163.78 | 191.28 | 301.27 | 150.63 |
| OP DDT | mg | 37.41 | 76.46 | 32.23 | 93.65 | 44.80 | 169.48 | 104.27 | 86.57 | 101.11 | 159.25 | 79.62 |
| PP DDT | mg | 129.48 | 264.65 | 111.54 | 324.14 | 155.07 | 586.59 | 360.88 | 299.64 | 349.94 | 551.16 | 275.58 |
| Dieldrin | mg | 94.22 | 192.58 | 81.17 | 235.87 | 112.84 | 426.86 | 262.61 | 218.04 | 254.65 | 401.07 | 200.54 |
| Hexachloroethane | mg | 21.28 | 43.48 | 18.33 | 53.26 | 25.48 | 96.39 | 59.30 | 49.23 | 57.50 | 90.56 | 45.28 |
| Trichlorobenzene 1-3-5 | mg | 57.31 | 117.14 | 49.37 | 143.47 | 68.64 | 259.64 | 159.74 | 132.63 | 154.90 | 243.96 | 121.98 |
| Hexachlorobutadiene | mg | 38.15 | 77.97 | 32.86 | 95.49 | 45.69 | 172.82 | 106.32 | 88.28 | 103.10 | 162.38 | 81.19 |
| Trichlorotoluene 2-4-5 | mg | 98.13 | 200.58 | 84.54 | 245.67 | 117.53 | 444.59 | 273.52 | 227.10 | 265.23 | 417.73 | 208.87 |
| Tetrachlorobenzene 1-2-3-5 | mg | 384.39 | 785.66 | 331.15 | 962.27 | 460.36 | 1,741.44 | 1,071.36 | 889.55 | 1,038.89 | 1,636.25 | 818.13 |
| Trichlorotoluene 2-6-A | mg | 90.33 | 184.63 | 77.82 | 226.13 | 108.18 | 409.23 | 251.77 | 209.04 | 244.14 | 384.51 | 192.26 |
| Pentachlorobenzene | mg | 73.30 | 149.81 | 63.14 | 183.49 | 87.78 | 332.06 | 204.29 | 169.62 | 198.10 | 312.01 | 156.00 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | | | | | |
| Naphthalene | g | 30.10 | 61.50 | 25.90 | 75.30 | 36.00 | 136.20 | 83.80 | 69.60 | 81.30 | 128.00 | 64.07 |
| Acenaphthylene | g | 2.10 | 4.30 | 1.80 | 5.20 | 2.50 | 9.40 | 5.80 | 4.80 | 5.60 | 8.90 | 4.54 |
| Acenaphthene | g | 10.20 | 20.90 | 8.80 | 25.60 | 12.20 | 46.30 | 28.50 | 23.60 | 27.60 | 43.50 | 21.74 |
| Fluorene | g | 16.10 | 32.90 | 13.90 | 40.30 | 19.30 | 73.00 | 44.90 | 37.30 | 43.50 | 68.50 | 34.40 |
| Phenanthrene | g | 133.80 | 273.50 | 115.30 | 334.90 | 160.20 | 606.10 | 372.90 | 309.60 | 361.60 | 569.50 | 285.39 |
| Anthracene | g | 5.60 | 11.40 | 4.80 | 14.00 | 6.70 | 25.30 | 15.50 | 12.90 | 15.10 | 23.70 | 11.91 |
| Fluoranthene | g | 181.20 | 370.30 | 156.10 | 453.50 | 217.00 | 820.70 | 504.90 | 419.20 | 489.60 | 771.10 | 386.32 |
| Pyrene | g | 122.00 | 249.30 | 105.10 | 305.30 | 146.10 | 552.50 | 339.90 | 282.20 | 329.60 | 519.10 | 260.06 |
| Benzo (A) Anthracene | g | 40.40 | 82.50 | 34.80 | 101.10 | 48.40 | 182.90 | 112.50 | 93.40 | 109.10 | 171.90 | 86.18 |
| Chrysene | g | 80.20 | 163.80 | 69.10 | 200.70 | 96.00 | 363.10 | 223.40 | 185.50 | 216.60 | 341.20 | 170.86 |
| Benzo (B) Fluoranthene | g | 130.20 | 266.20 | 112.20 | 326.00 | 156.00 | 590.00 | 363.00 | 301.40 | 352.00 | 554.40 | 277.83 |
| Benzo (B-K) Fluoranthene | g | 85.60 | 175.00 | 73.70 | 214.30 | 102.50 | 387.80 | 238.60 | 198.10 | 231.40 | 364.40 | 182.57 |
| Benzo (A) Pyrene | g | 59.10 | 120.80 | 50.90 | 147.90 | 70.80 | 267.70 | 164.70 | 136.70 | 159.70 | 251.50 | 126.06 |
| Indeno (1-2-3 C-D) Pyrene | g | 28.40 | 58.10 | 24.50 | 71.10 | 34.00 | 128.70 | 79.20 | 65.80 | 76.80 | 121.00 | 60.67 |
| Dibenzo (A-H) Anthracene | g | 13.40 | 27.30 | 11.50 | 33.50 | 16.00 | 60.60 | 37.30 | 31.00 | 36.20 | 57.00 | 28.54 |
| Benzo (G-H-I) Perylene | g | 33.70 | 69.00 | 29.10 | 84.50 | 40.40 | 152.90 | 94.10 | 78.10 | 91.20 | 143.60 | 72.01 |

Notes: * regression estimate used,    # traditional method used

**TABLE A4.11    PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH**

| PARAMETER | UNITS | CATCHMENT AREA | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | S12 925 | S13 913 | S14 911 | S15 909,915 | S16 927 | S17 | S18 919 |
| **GENERAL CHEMISTRY** | | | | | | | | |
| Chemical Oxygen Demand | T | 275.00 | 161.00 | 115.00 | 109.00 | 152.00 | 150.50 | 474.08 |
| Hardness | T | 76.00 | 44.50 | 31.60 | 30.20 | 42.00 | 41.60 | 131.04 |
| Phenolics (4AAP) | g | 6,189.00 | 3,630.00 | 2,580.00 | 2,460.00 | 3,420.00 | 3,385.00 | 10,662.75 |
| Total suspended solids | T | 45.00 | 26.30 | 18.70 | 17.80 | 24.80 | 24.60 | 77.49 |
| Ammonium | kg | 86.90 | 50.90 | 36.10 | 34.50 | 48.00 | 47.50 | 149.63 |
| Nitrates | kg | 1,144.00 | 668.00 | 474.00 | 452.00 | 630.00 | 623.00 | 1,962.45 |
| Nitrite | kg | 18.80 | 11.00 | 7.83 | 7.47 | 10.40 | 10.30 | 32.45 |
| Total Kjeldahl Nitrogen | kg | 890.00 | 522.00 | 370.00 | 353.00 | 492.00 | 487.00 | 1,534.05 |
| Total Phosphorus | kg | 184.00 | 108.00 | 76.80 | 73.20 | 102.00 | 101.00 | 318.15 |
| **BACTERIOLOGY** | | | | | | | | |
| E-Coli | TCts | 13,700,000.00* | 8,030,000.50* | 5,710,000.50* | 5,440,000.00* | 7,580,000.00* | 7,500,000.00 | 23,625,000.00 |
| Fecal Coliform MF | TCts | 19,700,000.00* | 11,500,000.00* | 8,179,999.50* | 7,799,999.50* | 10,900,000.00* | 1,790,000.00 | 33,988,500.00 |
| **HEAVY METALS** | | | | | | | | |
| Silver | g | 1,082.00 | 636.00 | 452.00 | 431.00 | 600.00 | 549.00 | 1,729.35 |
| Aluminum | kg | 608.00 | 356.00 | 253.00 | 241.00 | 336.00 | 332.00 | 1,045.80 |
| Arsenic | g | 258.00# | 212.00# | 151.00# | 144.00# | 200.00# | 198.00# | 623.70 |
| Barium | kg | 17.10 | 9.96 | 7.08 | 6.75 | 9.40 | 9.30 | 29.30 |
| Cadmium | g | 1,081.00 | 636.00 | 452.00 | 431.00 | 600.00 | 549.00 | 1,729.35 |
| Chromium | g | 5,066.00 | 2,970.00 | 2,110.00 | 2,010.00 | 2,800.00 | 2,772.00 | 8,731.80 |
| Copper | kg | 43.50 | 25.40 | 18.10 | 17.20 | 24.00 | 23.80 | 74.97 |
| Iron | kg | 1,664.00 | 973.00 | 691.00 | 659.00 | 918.00 | 908.00 | 2,860.20 |
| Mercury | g | 21.30 | 12.50 | 8.89 | 8.47 | 11.80 | 11.70 | 36.86 |
| Manganese | kg | 51.60 | 36.00 | 25.60 | 24.40 | 34.00 | 33.70 | 106.16 |
| Nickel | g | 3,984.00 | 2,330.00 | 1,660.00 | 1,580.00 | 2,200.00 | 2,178.00 | 6,860.70 |
| Lead | kg | 18.40 | 10.80 | 7.68 | 7.32 | 10.20 | 10.10 | 31.81 |
| Selenium | g | 362.00# | 212.00# | 151.00# | 144.00# | 200.00# | 198.00# | 623.70 |
| Zinc | kg | 65.00 | 38.20 | 27.10 | 25.80 | 36.00 | 35.60 | 112.14 |

Notes: * regression estimate used,   # traditional method used,   Tct=10^12 counts

**TABLE A4.12     PREDICTIVE SUMMER/FALL LOADING ESTIMATES FOR SCARBOROUGH**

| PARAMETER | UNITS | S12 925 | S13 913 | S14 911 | S15 909,915 | S16 927 | S17 | S18 919 |
|---|---|---|---|---|---|---|---|---|
| **ORGANOCHLORIDE PESTICIDES/CHLOROBENZENES** | | | | | | | | |
| Alpha-BHC | mg | 702.00 | 411.00 | 292.00 | 279.00 | 388.00 | 384.00 | 1,209.60 |
| Gamma-BHC | mg | 535.00 | 314.00 | 223.00 | 213.00 | 296.00 | 293.00 | 922.95 |
| 1,3,5-Trichlorobenzene | mg | 745.00 | 437.00 | 310.00 | 296.00 | 412.00 | 408.00 | 1,285.20 |
| 1,2,4-Trichlorobenzene | mg | 1,695.00 | 990.00 | 703.00 | 671.00 | 934.00 | 925.00 | 2,913.75 |
| 1,2,3-Trichlorobenzene | mg | 760.00* | 445.00* | 316.00* | 302.00* | 420.00* | 416.00* | 1,310.40 |
| Hexachlorobenzene | mg | 115.37 | 67.56 | 48.00 | 45.76 | 63.74 | 62.91 | 198.23 |
| PP DDE | mg | 59.14 | 34.64 | 24.60 | 23.46 | 32.67 | 32.25 | 101.62 |
| Alpha Chlordane | mg | 244.79 | 143.36 | 101.84 | 97.10 | 135.24 | 133.48 | 420.60 |
| Gamma Chlordane | mg | 216.39 | 126.72 | 90.02 | 85.84 | 119.55 | 118.00 | 371.80 |
| OP DDT | mg | 114.38 | 66.98 | 47.58 | 45.37 | 63.19 | 62.37 | 196.53 |
| PP DDT | mg | 395.87 | 231.84 | 164.69 | 157.04 | 218.72 | 215.87 | 680.20 |
| Dieldrin | mg | 288.07 | 168.71 | 119.84 | 114.27 | 159.16 | 157.09 | 494.98 |
| Hexachloroethane | mg | 65.05 | 38.09 | 27.06 | 25.80 | 35.94 | 35.47 | 111.77 |
| Trichlorobenzene 1-3-5 | mg | 175.23 | 102.62 | 72.90 | 69.51 | 96.81 | 95.55 | 301.08 |
| Hexachlorobutadiene | mg | 116.63 | 68.30 | 48.52 | 46.27 | 64.44 | 63.60 | 200.40 |
| Trichlorotoluene 2-4-5 | mg | 300.04 | 175.71 | 124.82 | 119.02 | 165.77 | 163.61 | 515.54 |
| Tetrachlorobenzene 1-2-3-5 | mg | 1,175.25 | 688.27 | 488.93 | 466.20 | 649.31 | 640.87 | 2,019.35 |
| Trichlorotoluene 2-6-A | mg | 276.18 | 161.74 | 114.90 | 109.56 | 152.59 | 150.60 | 474.54 |
| Pentachlorobenzene | mg | 224.10 | 131.24 | 93.23 | 88.90 | 123.81 | 122.20 | 385.06 |
| **POLYNUCLEAR AROMATIC HYDROCARBONS** | | | | | | | | |
| Naphthalene | g | 91.90 | 53.80 | 38.30 | 36.50 | 50.80 | 50.10 | 157.82 |
| Acenaphthylene | g | 6.40 | 3.70 | 2.70 | 2.50 | 3.50 | 3.50 | 11.03 |
| Acenaphthene | g | 31.20 | 18.30 | 13.00 | 12.40 | 17.30 | 17.00 | 53.55 |
| Fluorene | g | 49.20 | 28.80 | 20.50 | 19.50 | 27.20 | 26.80 | 84.42 |
| Phenanthrene | g | 409.10 | 239.60 | 170.20 | 162.30 | 226.00 | 223.10 | 702.77 |
| Anthracene | g | 17.10 | 10.00 | 7.10 | 6.80 | 9.40 | 9.30 | 29.30 |
| Fluoranthene | g | 553.90 | 324.40 | 230.40 | 219.70 | 306.00 | 302.00 | 951.30 |
| Pyrene | g | 372.90 | 218.40 | 155.10 | 147.90 | 206.00 | 203.30 | 640.40 |
| Benzo (A) Anthracene | g | 123.40 | 72.30 | 51.40 | 49.00 | 68.20 | 67.30 | 211.99 |
| Chrysene | g | 245.10 | 143.50 | 102.00 | 97.20 | 135.40 | 133.60 | 420.84 |
| Benzo (B) Fluoranthene | g | 398.20 | 233.20 | 165.70 | 158.00 | 220.00 | 217.10 | 683.87 |
| Benzo (B-K) Fluoranthene | g | 261.70 | 153.30 | 108.90 | 103.80 | 144.60 | 142.70 | 449.50 |
| Benzo (A) Pyrene | g | 180.60 | 105.80 | 75.10 | 71.70 | 99.80 | 98.50 | 310.28 |
| Indeno (1-2-3 C-D) Pyrene | g | 86.90 | 50.90 | 36.10 | 34.50 | 48.00 | 47.40 | 149.31 |
| Dibenzo (A-H) Anthracene | g | 40.90 | 24.00 | 17.00 | 16.20 | 22.60 | 22.30 | 70.25 |
| Benzo (G-H-I) Perylene | g | 103.20 | 60.40 | 42.90 | 40.90 | 57.00 | 56.30 | 177.35 |

Notes: * regression estimate used,   # traditional method used